

Agricultural Research Institute, Pusa

**Progress of the Sugarcane Industry in India
during the years 1916 and 1917**

*Being Notes submitted to the Meeting of the
Board of Agriculture in India, Poona, 1917*

Edited, with an Introduction, by

C. A. BARBER, C.I.E., Sc.D., F.L.S.,

Chairman of the Sugar Committee of the Board of Agriculture in India, 1917



CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1919

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

IN EUROPE.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.	Luzac & Co., 46, Great Russell Street, London, W.C.
Kegan Paul, Trench, Trübner & Co., 88-74, Carter Lane, E.C., and 25, Museum Street, London, W.C.	W. Thacker & Co., 2, Creed Lane, London, E.C.
Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.	T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.
P. S. King & Sons, 2 & 4, Great Smith Street, Westminster, London, S.W.	Wm. Wesley & Son., 28, Essex Street, Strand, London.
H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.	B. H. Blackwell, 50 & 51, Broad Street, Oxford.
Grindlay & Co., 54, Parliament Street, London, S.W.	Deighton Bell & Co., Ltd., Cambridge.
	Oliver and Boyd, Tweeddale Court, Edinburgh.
	E. Ponsonby, Ltd., 116, Grafton Street, Dublin.
	Ernest Leroux, 28, Rue Bonaparte, Paris.
	Martinius Nijhoff, The Hague, Holland.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.	Gopal Narayan & Co., Bombay.
Newman & Co., Calcutta.	Rangachandra Govind & Son, Kalthadevi, Bombay.
B. Cambay & Co., Calcutta.	A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.
S. K. Lahiri & Co., Calcutta.	N. B. Mathur, Supt., Nazir Kanun-i-Hind Press, Allahabad.
B. Banerjee & Co., Calcutta.	Rai Sahib M. Gulab Singh & Sons, Muldd-Idam Press, Lahore and Allahabad.
The Indian School Supply Depot, 300, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca.	Rama Krishna & Sons, Lahore.
Butterworth & Co. (India), Ltd., Calcutta.	Supt., Amvriam Baptist Mission Press, Bangalore.
Rai M. C. Sarear Bahadur and Sons, 60-2A Hurston Road, Calcutta.	Manager, the "Hitavada," Nagpur.
The Nelson Library, 13-5, Chowringhee Road, Calcutta.	S. C. Tabukdar, Proprietor, Students and Company, Cooch Behar.
Standard Literature Co., Limited, Calcutta.	A. M. & F. Ferguson, Colombo, Ceylon.
Lal Chand & Sons, Calcutta.	Manager, Educational Book Depôts, Nagpur and Jabalpur.*
Higginbothams, Ltd., Madras.	Manager of the Imperial Book Depot, 63, Chandney Chank Street, Delhi.*
V. Kalyanaram Iyer & Co., Madras.	Manager, "The Agra Medical Hall and Co-operative Association, Ltd." (Successors to A. John & Co., Agra).*
G. A. Natesan & Co., Madras.	Supt., Basel Mission Book and Tract Depository, Mangalore.*
S. Murthy & Co., Madras.	P. Varadachary & Co., Madras.*
Thompson & Co., Madras.	H. Liddell, Printer, etc., 7, South Road, Allahabad.*
Temple & Co., Madras.	Ram Dyal Agarwala, 184, Katra, Allahabad.*
P. B. Rama Iyer & Co., Madras.	D. C. Anand & Sons, Peshawar.*
Vas & Co., Madras.	Manager, Newal Kishore Press, Lucknow.*
E. M. Gopalakrishnan Kone, Madras.	
Thacker & Co., Ltd., Bombay.	
A. J. Cambridge & Co., Bombay.	
D. B. Tarasotevala, Sons & Co., Bombay.	
Mrs. Radhabai Atmaram Saigoom, Bombay.	
Sunder Pandurang, Bombay.	

* Agents for the sale of Legislative Department publications only.

INTRODUCTION

IT has been the custom in the past to collect the mass of notes prepared on the special subjects discussed at the meetings of the Board of Agriculture and to print them as appendices to its Proceedings. When it was decided on the last occasion to abbreviate the Proceedings by leaving out most of these notes, and thus keep the bulky volume within reasonable limits and also issue it more expeditiously, the Agricultural Adviser was approached as to the possibility of printing the notes on the progress of the sugar industry as a Bulletin of the Pusa Research Institute. This form of publication is, after all, much more suitable, for the Proceedings are often not readily available and the information contained in the appendices is liable to be overlooked. Thus far the notes on the sugar industry prepared for each meeting of the Board have been preserved and it was felt that it would be a pity to break the continuity of the record. The Agricultural Adviser has kindly agreed to this suggestion and has asked me, as Chairman of the Sugar Committee, to edit the bulletin and write an introduction. The note on the work of the experimental factory at Nawabganj, in the United Provinces, is not printed here, as it has been issued as a separate bulletin¹. No notes were received from Bengal and the North-West Frontier Province, but these have been subsequently prepared at special request, and are included with the rest.

On looking through the reports presented on this and previous occasions for discussion at the Board of Agriculture, the first thing that will strike any one interested in the progress of the sugar industry in India is the marked inequality of the amount of information recorded regarding different tracts, the amount of detail in no way corresponding to the importance of the work being done or the interests involved. This is, of course, partly a natural expression of the amount of personal attention given to the subject by the different authors of the notes. Some few of them are devoting their whole attention to sugar matters, while others have many other interests to engage their attention. Some of the notes have been written by chemists, botanists or agriculturists, and the point of view differs accordingly, whereas a number have been prepared by Directors of Agriculture, who are in charge of all the

¹ *Agric. Res. Inst., Pusa, Bulletin* no. 82.

activities of their Departments, and cannot therefore be expected to possess the detailed knowledge of the subject which is desirable.

As instances of the meagreness of the information presented concerning important tracts, the reports printed here of the Directors of Agriculture in the United Provinces and Bihar and Orissa may be specially referred to. In the former case, with a greater acreage under sugarcane than the whole of the rest of India put together, the work of the Shahjahanpur Research Station is practically unnoticed, doubtless in part due to the absence of Mr. Clarke from India at the time. The whole of the cultural and varietal work being carried out in the province is dealt with in one short paragraph, although, as will be seen later, the Director regards this as the most important part of the sugar work of the Department. In the report from Bihar, where the greatest number of the sugar factories in India are collected, no reference is made to their work at all. This will naturally be read as an indication that the Agricultural Department is not in touch with them; but a very much fuller and more useful report might have been presented by the Agricultural Chemist, who has devoted much time to sugar matters and done a good deal of useful work on the subject. The Bombay note contains no reference to the extremely promising and important extension of the sugarcane area in the tracts of the Deccan now being opened up by the new system of canals, although a newspaper cutting was afterwards added, at special request, by the Director of Agriculture, containing a summary of his evidence before the Indian Industrial Commission. The Burma note contains no information as to the progress of the Government scheme of opening up a new sugarcane area in the Mon Canal region. But instances need not be multiplied to demonstrate the very partial nature of the information placed before the Sugar Committee by the local authorities. The Committee expressed itself freely on the subject¹, and a general study of the material printed in this bulletin will furnish a strong condemnation of the system at present adopted, as it no longer meets the needs of the case. What is wanted is a much more thorough study of the industry from all points of view, and this bulletin presents a powerful argument for the formation of the Bureau of Sugar Information which the Board of Agriculture proposed should be started, consisting of specialists whose whole time should be devoted to the various aspects of this important industry throughout India.

That the sugar industry in India is in need of immediate attention is agreed to everywhere, and that this is fully realized by Government is obvious from the remarks of Sir Claude Hill in his opening address

¹ *Proceedings of the Board of Agriculture in India, Poona, 1917*, p. 78.

at the Poona meeting of the Board of Agriculture.¹ It is instructive to note the somewhat divergent views which are held, by different authorities, as to the special defects which are held to be fundamental, and which should be immediately attended to if any hopes of improvement are to be entertained. The process of manufacture of the raw product is admittedly of a very primitive nature and, although there is a steady improvement in many places, it is the belief of some that this is the limiting factor which must be attended to before any improvement can be hoped for. This point of view is a century old, and has recently been specially advocated by Mr. Sayer in a series of articles in the *Agricultural Journal of India*.² The principles of *gur*-making are undoubtedly in many places woefully wasteful, if not radically wrong. But is not this point of view to a certain extent influenced by the translation of *gur* into white sugar? The ryot prefers this *mixture*, and is even content to pay a higher price for it than for the pure white sugar. Looked at from this point of view, the loss in manufacture is perhaps somewhat exaggerated. The cultivation accorded to the sugarcane in a large part of India is also extremely primitive. For its improvement, much propaganda work is needed by the Agricultural Department, but this is complicated by the facts that it is extremely difficult to alter, by example or precept, agricultural practice which is firmly rooted, and that the treatment of the canes in the tropics is largely inapplicable to the canes grown in India. It is the opinion in some quarters that, before the cultivation is improved, it is comparatively idle to attempt the introduction of better varieties. Thus, in his note for the United Provinces, Mr. Hailey writes: "The main work of the Department is concentrated on teaching the people better methods of planting and cultivation, and it is believed that when these are more generally in force, the introduction of better classes of canes will necessarily follow; but, until adopted, the best results will not be obtained from the work on the research farm in this province or that at Coimbatore." Lastly, the kinds of cane grown all over the great sugarcane tract of India are easily the worst in the world, and it is believed by some that this is the basal defect in the industry and that, if better kinds are forthcoming, they will be readily taken up by the cultivator, and that improved cultivation and manufacture will be more likely to follow, when the increased production places the ryot in a better financial position. This is the object with which the Coimbatore farm was started. There is no doubt that the great expansion in the sugar industry in the Madras Presidency, during recent years, is mainly due to the good new

¹ *Proceedings of the Board of Agriculture in India, Poona, 1917*, p. 19.

² Vol. XI, pts. I and IV; and vol. XII, pt. IV.

kinds of cane introduced through the agency of the Samalkota farm in the Godavari District, and nowhere is this more forcibly exhibited than in the fine sugar factory at Nellikuppam in the South Arcot District.

These three lines of improvement are being continuously studied in all places where the Agricultural Department interests itself in the improvement of the sugar industry, as will be sufficiently obvious if we read between the lines of the various notes brought together in this bulletin. Which direction of work is the more urgent will depend largely on the locality and the conditions of the industry in it, but the general question is of more or less academic interest, for all three are being simultaneously followed in each province. It is, however, none the less a defect that these efforts are detached and independent, little being known in one province of what is being done in another, what methods are being adopted and what lines of work have been found to be most successful. And it is this fact that has led the Board of Agriculture unanimously to support the suggestion of the Sugar Committee that an Imperial Sugar Bureau should be formed, whose duty will be to collect and collate the results obtained in various directions, and thus to be in a position to assist the isolated efforts in different parts of the country with sound advice, based on experience gained by a general survey of the work done in India now and in the past, and that accomplished in other countries.

C. A. BARBER,

*Chairman of the Sugar Committee
of the Board of Agriculture in India, 1917.*

COIMBATORE ;
25th September, 1918.

Progress of the Sugarcane Industry in India during the years 1916 and 1917

(1)

MADRAS.

(a)

(G. A. D. STUART, I.C.S., *Director of Agriculture.*)

A note by Dr. Barber on the progress at the Cane-breeding Station is appended, and also a note by the same officer on the general question of the possibility of increasing the production of sugar in India, originally prepared in 1916 for the Industrial Commission.

The testing of varieties at five agricultural stations has continued. On the East Coast, B. 3412 has been found to give a good yield of high quality jaggery, 4.6 tons to the acre, but this cane is soft and very liable to disease when grown under the water-logged conditions of the paddy area. Another variety, J. 247, which is a harder cane giving a somewhat smaller yield, appears to be immune to red-rot, and for this reason is likely to prove of great value in these areas. District work has consisted of the introduction of proved varieties, and the advocacy of smaller seed-rate and planting in rows where these practices are unknown. Iron mills are now universally used, but the local *jaggery*-boiling furnaces are often wasteful of fuel and the Department has been successful in getting these improved in places. In parts of the South Kanara District on the West Coast the cane is grown by sub-tenants who are too poor to manufacture *jaggery* and so sell their cane at low rates to professional *jaggery*-makers. An attempt is being made to start co-operative manufacture by the growers.

Two experimental *jaggery*-making plants, each consisting of a twelve horse-power oil engine, a 12 inches three-roller mill, and a battery of *jaggery* pans, were taken over from the Department of Industries last year. Full figures of production and cost had not always

been properly maintained in the past. Those obtained last year showed that the net cost of making *jaggery* from cane carted to the factory by ryots came to Rs. 2-2-0 per 250 lb. of *jaggery* made.

Messrs. Parry & Co. have continued to expand their manufacture of sugar direct from cane at Nellikuppam. They are employing steam tackle for the wholesale cultivation of land taken on lease from ryots. They have succeeded in persuading these to allow their field boundaries to be obliterated for the period of the lease, the boundary marks being sunk below the soil. Owing to the high price of *jaggery*, *jaggery*-making plants have been set up in the neighbourhood, however, and the company has had at times some trouble with particular cane-growers. But there has been no difficulty in securing as much cane as could be dealt with. The same company has commenced the manufacture of *massecuite* direct from cane at Anakapalle, the product being sent for refinement to their sugar factory at Samalkota. A similar sub-station is also working at Palghat in connexion with the Nellikuppam factory.

September, 1917.

NOTE. The following information has been received from the Manager of the Nellikuppam factory in South Arcot:—

OUT-STATION CRUSHING PLANTS.

We have installations at Valavanur and Tiruvannamallur. Each installation is equipped with three crushing sets, each set consisting of a three-roller mill directly coupled to a 10 horse-power steam engine and estimated to deal with 2 acres of cane per diem, i.e., 6 acres per installation per diem. The juice from the mill passes *via* a tubular juice heater (heated with exhaust steam of engine) to a transit evaporator (open fire) and finally to a steam finishing pan where it is boiled to the required density to make into a dry brown sugar, which is subsequently refined.

We can deal with about 1,400 acres thus.

(b)

Progress Report of the Cane-breeding Station.

(C. A. BARBER, Sc.D., *Government Sugarcane Expert.*)

Since the last meeting of the Board of Agriculture (in February 1916) a Memoir¹ has been issued containing details of the first three years' work on the Cane-breeding Station at Coimbatore. This contains also a fairly full study of the cane seedlings obtained during that period.

In this Memoir the character of the land was reported on, and it was shown that the acclimatization of the cane varieties collected on the

¹ "Studies in Indian Sugarcane, No. 2. Sugarcane seedlings, including some correlations between morphological characters and the sucrose in the juice." *Mem. Dept. Agri., India, Bot. Ser.*, vol. VIII, no. 3.

farm was far from complete. Special attention has been paid to this point and the layers of soil in various parts have been studied to a depth of six feet. It has been concluded that the main fault in the land is due to the rise of saline substances due to evaporation after rain or irrigation. This is being countered by green-manuring and by keeping the soil covered as much as possible, especially where cane is being grown. The result of this work has been satisfactory, the growth of canes and seedlings is good, and the acclimatization of the cane varieties may now be considered as complete.

Such being the case, it has been found possible to make a comprehensive study of the varieties of the indigenous canes collected. A paper has been prepared and submitted for publication as a Memoir¹ which, it is thought, will go far to solving the many difficulties in the classification of Indian canes. Studies have also been instituted in the mode of branching of the different varieties, and the growth of canes in different localities and under different conditions.

The special methods adopted to induce the canes to flower and thus produce seedlings have been greatly assisted by their fuller acclimatization, as will be seen from the following figures :—

Cane varieties flowering on the farm.

	Thick canes	Thin canes	
1912-13	3	3	
1913-14	0	0	Farm not fully laid out.
1914-15	5	4	
1915-16	35	36	Exceptionally favourable weather.
1916-17	63	34	

The natural result of this increased flowering has been a remarkable increase in the number of seedlings obtained. During the 1916-17 campaign, as many as 99,000 seedlings germinated, more than thrice those obtained in any previous year.

But the ideal seedling aimed at is a cross between a thick tropical and a thin indigenous variety, and success in this has hitherto been comparatively small. We have worked out a ready means now of determining male fertility in any arrow or variety, but the great stumbling block in cane seedling work has always been the absence of any criterion as to the female fertility of the flowers. The subject has

¹ "Studies in Indian Sugarcane, No. 3. The classification of Indian canes with special reference to the *Sacchara* and *Sumbabile* groups." *Mem. Dept. Agri., India, Bot. Ser.*, vol. 1X, no. 4.

been carefully studied by my first assistant and, apparently, successfully solved by the observation of the starch grains present in the stigmas. Besides this difficulty, the thick canes do not usually flower at the same time as the thin ones and, as the result of first five seasons' work, we managed to obtain less than 300 *probable* true crosses. With the convergence of all our lines of work, we have succeeded in the 1916-17 campaign in obtaining some 4,000 undoubted crosses of the desired nature. This is perhaps the outstanding piece of progress in the work of the Cane-breeding Station, and some 2,800 of these crosses are being grown on for analysis in 1918.

The whole of the sugarcane tracts in India have now been visited, at any rate partially, and we know fairly well what kind of seedling is likely to be useful in each of them. The most recent tract visited was Burma, and the result of that visit has been to convince us that the prospect of increase in acreage is more promising there than elsewhere, that the country is specially suited for the growth of thick canes, and that there is no inherent difficulty in the making of sugar on a large scale, if it is desired by Government to encourage the industry. A note has been prepared for the Industrial Commission on the subject of sugar production in India.

July, 1917.

(c)

Note on the Possibility of India's Producing its own Sugar or Becoming an Exporting Country.

(C. A. BARBER, SC.D., *Government Sugarcane Expert.*)

I. THE PRESENT HIGH PRICE OF SUGAR AND THE QUESTION OF ITS PERMANENCE.

There is a marked shortage in the supply of sugar all the world over. This appears to me to be due to two main causes. In the first place, there is a rapidly increasing consumption *per capita* in all countries, and, secondly, the huge supplies of beet sugar, hitherto exported from Germany, Austria, and France, have been entirely cut off by the war. The world's pre-war consumption was about 18,000,000 tons yearly, and beet and sugarcane were credited with about 9,000,000 tons each. The price of sugar is at present extremely high, and I regard as probable that the longer the war lasts the higher will it rise.

India has, as is well known, imported increasing quantities of sugar during recent years, the annual total reaching not far short of a million

tons. This imported sugar used to come largely from Austria, more recently Mauritius entered the market, but at present it comes almost exclusively from Java. The world's shortage has made itself felt in India in that the retail price has nearly doubled. Can India, taking advantage of this, produce this sugar herself? Can she indeed look forward in the future to becoming an exporting country as she once was?

There are two basal factors to be considered before approaching this question. We do not know whether this rise in price will be more or less permanent, or whether, after the war, it will sink again to its former low level, and it is not an easy matter to start a sugar factory, and several years must elapse before the solid foundations of such an enterprise can be laid. Sugar-making in India must be considered to a large extent as a new industrial enterprise, and the difficulties in the way are much greater here than in any tropical country where the cane is grown. A vital question is the price of sugar after the war. I have formed the opinion that it will take many years before it sinks to pre-war level, if it ever does. And I base this opinion on the following facts and considerations :—

- (1) There is a constantly increasing consumption of sugar in all countries, and one effect of the war will be, I think, to give an impetus to this. I regard this increase as a permanent feature for many years to come.
- (2) It seems probable that the British Government will take some steps to prevent the free dumping of sugar on the market by countries at present at war with us, and this will inevitably lead to an enhancement of the price.
- (3) There is a considerable dislocation in the beet-growing area in Europe, because the war has selected for its activities the particular area where beet is grown, and there has been a great and calculated destruction of property there. There will thus be less total sugar available. There is considerable shortage, even in Germany in spite of the cutting off of the whole of her export trade, and one of the lessons of the war will, I believe, be that it will be considered economical for much more sugar to be retained for internal consumption, both by man and beast, than was formerly done, in all beet-growing countries.
- (4) With one exception of importance, to be noted below, I do not apprehend any immediate great extension of sugarcane tracts in the tropics. The following is, according to my idea, the position of affairs. There

are a very great number of countries in which the sugarcane is grown, and great strides have been made, both in field and factory, during the last twenty years of agricultural revival. It does not seem likely that further improvements or extensions will be more than sufficient to keep pace with the normal increasing demand, with one possible exception. For the sake of brevity, I will merely consider Java and Cuba, easily the greatest producers at the present time. There are many reasons for thinking that Java has nearly reached the limits of its production, as the past few years, in spite of strenuous scientific control, have shown decreased out-turn on the estates, and it is generally conceded that practically all the good sugarcane land has already been taken up. With Cuba it is different. It is a great unknown factor. But there are interesting figures available which show that this country is worthy of special attention. It is, indeed, quite within the bounds of possibility that, in the near future, it may dominate the sugar position much as Brazil has done that of coffee. It has not, moreover, as yet been possible or necessary to bring to bear on it the laborious scientific work which has characterized the industry in Java, Mauritius, the West Indies, Louisiana, Hawaii and other places. It will be seen from the following figures that there is a great future in store for the Cuban sugarcane crop.

Cuba's sugar production.

Before the war of 1893, it had reached 1,000,000 tons a year.	
1897-1900	200,000 to 300,000 tons.
1901-1903	600,000 to 1,000,000 tons.
1904-1912	1,000,000 to 2,000,000 tons.
1913-1916	2,000,000 to 3,000,000 tons.

It is considered by some that the output this year may reach 3,500,000 tons. There are, I believe, great areas of rich land at present unworked, and capital and machinery are pouring into the country. There is little doubt that an important factor is thus introduced, which may have great influence on the future price of sugar.

II. THE DIFFICULTIES IN INDIA.

(1) *The class of canes grown in India.* Roughly speaking, there are two great sugarcane tracts in India, which differ fundamentally. The

first is that in which thick tropical canes can be grown to maturity, often as well as in Java or the West Indies, the second is entirely given up to thin, hardy, fibrous, indigenous varieties generally unsuited for the economic production of sugar.

The first region consists of the Peninsula (Madras, Mysore, the lower parts of Bombay and the Central Provinces) and, curiously enough, Assam and Burma. This is the natural sugarcane tract and is, in the main, in the tropics. The inclusion of Assam is due to its moist, equable climate, in which it resembles, perhaps more than any other part of India, the cane conditions of such a tropical island as Antigua.

The second region is extra-tropical. Bengal and Bihar may be regarded as transitional, but, after passing the Rajmahal range of hills, a great change is noticeable in the character of the flora and the crops grown. We soon enter the wheat region, as contrasted with that of sugarcane. This region includes the alluvial plains of the Ganges and Indus and extends into the north of the Central Provinces and probably of Bombay.

Now it is a curious fact, and a constant source of mystification to those not conversant with Indian conditions, that the acreage under cane in the sugarcane tract is comparatively insignificant, and at least 90 per cent. of it is to be found in what I have summarily termed the wheat tract. This is one fundamental difficulty in any extension of sugar-making in India. I am not prepared to discuss its causes in detail here, but would merely suggest that in the past, with comparative lack of communications and the presence of hardy indigenous kinds, the need of sugar or its equivalent *gur* caused the sugarcane to become an integral part of the cultivation in North India, whereas the smaller populations of the south were more accessible from outside and had other sources of supply in their palm forests. Furthermore, irrigation was necessary there, and the expenses generally of cultivating the thick tropical canes were out of all proportion greater than those of the northern kinds, and this undoubtedly checked expansion in the south.

(2) *Competition with gur.* Besides the unsuitable character of the canes grown, a second difficulty in the way of extension of sugar-making in India is the fact that, beyond the importation referred to above, sugar is not an essential food of the people. They prefer *jaggery* or *gur*, an extremely impure form of sugar, which cannot, as a rule, be economically used as a raw material for sugar-making. The great mass of the sugarcane grown in the country is used in the preparation of this commodity. The price is comparatively unaffected by the fluctuations in the world's sugar market, and the chief factors influencing the extension of cane cultivation are the general increase

in population and the rise in the scale of living, the character of the season, and the prices of such other staples as are grown interchangeably with it. The relative profitableness of the conversion of the cane juice into *gur* and sugar has therefore to be considered in each tract before any decision can be reached as to the possibility of founding a sugar factory there. I am not in a position to discuss this question in its commercial aspects, but would merely draw attention to the fact that the contest between the two products is very unequal. *Gur*-making can be conducted by anyone who has the canes growing, accurate tests regarding ripeness are unnecessary, no capital is required, and the practice can be discontinued at any time. Sugar-making is a new enterprise in India, requires large capital and the difficult combination of many growers, can only be instituted after considerable preparation, and cannot be discontinued without serious financial loss.

(3) *Subdivision of the land.* These difficulties are emphasized by the opinion, general in sugar-making countries, that for commercial success, the enterprise should be carried on on as large a scale as possible. A large block of land is needed, so compact as to reduce the heavy carting charges to a minimum, and the factory should have control over the fields so that it is kept constantly and evenly supplied with the canes. In the settled parts of the country, the holdings are small, and such sugarcane as is grown is in scattered plots of small size. It is impossible to alienate the land for an enterprise of this kind, and it is difficult for any control to be exercised by the factory. This is a very important difficulty and practically rules out large areas in the sugarcane tract from the possibility of sugar-making.

(4) *Competition with other crops.* The whole question of obtaining lands for sugarcane-growing will ultimately depend on the relative profitableness of the crops usually grown. This will be referred to later, but it should be stated here that this rivalry varies with the tract, paddy being a serious rival in the irrigated parts of the Peninsula and in parts of Bengal, jute being the main rival in the sugarcane land of Bengal and cotton in the canal tracts of the Punjab. These crops are not likely to be displaced and the extension of sugarcane in such areas is therefore unlikely.

Summarizing, the extension of sugar-making in India is handicapped by the extremely poor character of the canes grown, by the unequal competition of *gur* where it has a steady and satisfactory market, by the relative cost of initiating *gur* and sugar-making, by the extreme subdivision of the land which renders it impossible to work a factory economically, and by the competition of crops already on the land and

which can be easily and profitably grown. We must turn to places where the price of *gur* is low, where the land is not fully settled, and where it is possible to introduce a better class of cane varieties.

III. PROSPECTS IN THE DIFFERENT PROVINCES.

I propose now briefly to pass under review the various tracts in India where sugarcane is grown, in order to emphasize the fact that each has its own peculiar difficulties, and, incidentally, to see in which directions progress is more likely to be effected.

Madras can grow sugarcane as well as any average place in the tropics. It, however, requires irrigation, and thus comes into competition with irrigated crops, mainly paddy. The latter crop is perhaps the easiest to grow in Madras, while sugarcane is one of the most laborious and the most expensive. With present prices of paddy and the possibility of growing more than one crop in the year, it is not likely that sugarcane will to any large extent replace it, even under favourable conditions. Where, however, large quantities of subterranean water are available, paddy competition is ruled out and the matter is less complicated, in that garden crops (those irrigated from wells) also require a good deal of labour. *Ragi* (*Eleusine coracana*), groundnut, and *cholam* (*Andropogon Sorghum*) may be regarded as typical of these. These are the new competitors, and the sugarcane has a better chance, especially as the individual fields are larger. As an example of successful work in sugar-making in such a tract, I would refer to the sugar factory at Nellikuppam in South Arcot. Here, with a better class of cane introduced by the work of the Samalkota Government farm, with large stores of subterranean water and an easily workable soil, sugarcane cultivation has made great strides. By suitable advances, the distribution of manure, and the abundant supply of water by powerful engines, it has been found possible to induce the ryots to grow large fields of sugarcane and bring the canes to the factory. But such areas are rare indeed in Madras, and it has always seemed to me as if a bit of the alluvial plain of the Ganges had been here inserted between the hard red and stiff clay soils of the Peninsula. The tract is, in fact, composed of the alluvium of two rivers, the Gadilam and Ponnai, and is the centre of the groundnut cultivation in India. From what I know of the conditions prevailing in other parts of the Madras Presidency, I do not consider it likely that any great extension of the sugarcane cultivation will take place, and the foundation of many sugar factories appears to be less likely still. I have dealt with Madras rather

fully because it can grow such good thick canes, and this fact is constantly laid hold of by those who wish to extend sugar-making in India.

Mysore. I am not very conversant with the conditions in Mysore, but a good deal of sugarcane is grown there. It is not a paddy country and the population is comparatively sparse. The rainfall is not great and irrigation is necessary. With the extension of irrigation projects or the discovery of subterranean water supplies, it is not inconceivable that sugar factories may be started, but I would defer to the opinion of the Director of Industries, who has, I believe, made a special study of the question.

Bombay. Here the problem is again entirely different. The competition of paddy is removed. Excellent cane crops are raised on the rich volcanic soils, and the juice is very rich in sucrose. Yet the area under sugarcane is insignificant. New irrigation projects are nearing completion in unoccupied tracts, and it is expected that a large part of these will be planted with sugarcane. Whether this is utilized for *gur* or sugar-making will presumably depend on the prices ruling, but it should not be difficult to obtain large compact blocks if the latter is decided on and the capital is available.

The Central Provinces. These are on the line of demarcation between the two great sugarcane tracts in India, and excellent crops of thick canes can be grown in the southern part of the area. The population is sparse, and there is a considerable development taking place in opening up new irrigation works, by which considerable areas will be available for sugarcane-growing. There is indeed reasonable hope that a great deal more sugarcane will be grown in the near future. But the amount grown is at present extremely small, the price of *gur* is very high, and the local Agricultural Department do not consider that sugar manufacture can be undertaken on the new land in competition with *gur*.

Bengal is a great paddy-growing country, but this is chiefly in low-lying land unsuited for sugarcane. The higher land, with sufficient water to do without irrigation, is, however, fully occupied by jute, which has nothing to fear from competition with sugarcane. Good thick canes can be grown in many parts but, in spite of this, the varieties are, on the whole, exceedingly poor and primitive. There is undoubtedly room for considerable improvement here, but the Agricultural Department is under special difficulties in Bengal. The population is very dense, and I do not think it likely that large blocks will be available for sugarcane-growing, even with improved varieties.

Assam. The unique geographical conditions of Assam have already been referred to. The population is very sparse and there are large unoccupied areas in Lower Assam on both sides of the Brahmaputra.

The unhealthiness of the country has, I believe, improved of late years, and there is some likelihood of the increasing masses of Bengal pushing their way into the Assam valley. An experiment on a large scale has been made by Government, to see if these great unoccupied areas can be utilized for the growing of sugarcane. The first stage in this experiment has now been reached, and it is evident that, with certain precautions, thick canes can be grown with great ease over large areas of the grass land in Kamrup. There are special difficulties in the way, such as control of surface water, absence of communications, and scarcity of labour which has to be introduced, but these are to all appearances being successfully overcome, and the prospect is distinctly encouraging. There is a very large amount of land of a nature similar to that on which the farm is placed. The local price of *gur* is, I believe, high, but the demand is not excessive, and it seems more probable that the limiting factor will be the prices ruling in the great Bengal market.

Bihar. The canes in North Bihar are the thin indigenous ones common in North India, although there are some indications that selected thick canes may be grown with advantage. Bihar is, in fact, to some extent a transitional region between the great sugarcane tract in North India and the more tropical area of Bengal and Assam. There are a number of sugarcane factories working, and these, I believe, are, in the main, successful. I am led to think that this success is largely due to the fact that the country is one in which the European planter has worked for many years. He has capital, a crop is needed to replace indigo, the people have long been accustomed to work with him and grow the crops for his factories; he has a certain amount of control over the crops grown and not infrequently a certain amount of land is attached to the factory to form a basis for cultivation. The price of *gur*, although rather high at present, is, I believe, as low as anywhere in India, so that, from the contiguous part of the United Provinces, it is sent as far as the Central Provinces and the Punjab. The pressing need in Bihar is, to my mind, the suitable location of a first class sugar station where varietal and other experiments can be instituted with a suitable staff for combined work with the planters. I am told that the local agriculture leaves much to be desired and the canes certainly need replacing by better varieties.

United Provinces and Punjab. The special conditions in Bihar and Assam are absent further north-west, and the prospects become increasingly less satisfactory. The canes grown are excessively thin and fibrous, the yield per acre is small, and the percentage of sucrose in the juice is often low. This would, furthermore, greatly enlarge the area required for an up-to-date factory, with an increase in the cost

of cartage. The fields are small and scattered and the cultivators are unaccustomed to sell their crops to a central factory. I do not think that there is much prospect of instituting sugar factories in this region, under present conditions.

IV. WORK IN PROGRESS.

A great deal of work is being carried out on this crop by different Agricultural Departments, but this is scattered and deals with purely local problems. Two experts have been entertained by the Government of India, both of whom are located in provinces and under the local authorities. A Sugar Engineer is engaged in the United Provinces and a Sugarcane Expert in Madras. With the work of the former I am not acquainted, and I propose here only to deal with the latter, in that I consider that the fundamental problem before India is the improvement of the class of canes grown. This is the problem for the solution of which the Cane-breeding Station has been started at Coimbatore. The main line of work is to replace the local North Indian canes by seedling canes, and this, unfortunately, cannot be done in North India because the sugarcane does not flower there. Attempts are being made to obtain new varieties by crossing thin indigenous canes with thick tropical ones, thus combining useful characters of the two classes. Hardy, moderately thin, rich canes are aimed at, which will grow in North India to maturity and be able to withstand the local indifferent treatment at the hands of the ryot. That such an ideal is not unattainable is shown, in the first place, in that crosses have been obtained, although not at present in sufficient quantity or sufficiently studied for distribution, and secondly, because a trial of such a cross has been rendered possible by work in Java. A seedling cane raised there under the No. Java 36 was obtained in Madras and forwarded for trial by the Sugarcane Expert to Shahjahanpur. It was obtained in Java by crossing the local Chunnee of Shahjahanpur with the rich Cheribon of Java. It has been tested now for some years at the Shahjahanpur farm by Mr. Clarke, and the latest accounts have been very favourable, in that last year all the available sets (some nine lakhs in number) were eagerly taken up by the cultivators. Another variety was introduced by the advice of the Sugarcane Expert into the Partabgarh farm, and it has rapidly extended until, in the present year, some hundred acres are under it near that place. These two cases are given as a sample of the work which it is intended to carry out when the new varieties being evolved at Coimbatore are ready for distribution. Altogether some 130,000 cane seedlings have been raised

at the Cane-breeding Station, and it is confidently anticipated that, from among these, and those still being obtained, it will be possible to allocate suitable seedlings for every part of India. It has been estimated that the results of the introduction of new and better canes into Madras some years ago by the Samalkota Sugar Station have culminated in a gain of Rs. 25 per acre, totalling rupees 25 lakhs a year. If the improvement in North India reaches the modest sum of Rs. 5 per acre, it will mean ten crores a year in the ryots' pockets.

It is perhaps needless to point out that if such an improvement can be brought about, the question of sugar-making in India will enter on an entirely new phase. The price of *gur* would be regulated all over the country and possibly considerably reduced by the greater yields obtainable, and there would be a surplus available with more suitable cane varieties for the flotation of sugar-making concerns. But the whole question has its complications, and I do not think that useful results can be obtained with certainty, unless a large view is maintained and the work is properly organized.

V. FOUNDING OF A SUGAR DEPARTMENT FOR INDIA.

For this purpose I would suggest the formation of a small Sugar Department for India, to be placed directly under the Agricultural Adviser to the Government of India. I would indicate some of its objects in the following manner, but it is inevitable that the relative importance of the different lines of work would only be clearly understood as progress could be reported :—

(1) The collection into one office of the scattered information recorded regarding the character of the sugarcane tracts in India, the varieties grown, the methods of cultivation and of making the finished product.

(2) The collection of similar information regarding all previous attempts at founding sugar factories, with the reasons for their discontinuation.

Much of this information (under 1 and 2) is now to be found in the files of various Secretariat and other offices in the provinces, but it is not available, and it is desirable to get it together, collate it, and, doubtless in some cases, to publish it in book form or otherwise to serve as a basis for future work.

(3) A continuation of the work on improving the class of canes growing in different parts of the country.

14 PROGRESS OF SUGARCANE INDUSTRY IN INDIA, 1916 AND 1917

(4) An organized investigation into the local practices of *gur*-making throughout the country, with the object of introducing improvements according to the local conditions.

(5) A special study of the possibility of starting a sugar-making industry in the various tracts where sugarcane is grown.

For such a Department to be effective I would suggest the attachment of the following experts :—

- (1) A Sugar factory Expert. He should be thoroughly acquainted with the conditions in India as regards factory work, labour difficulties, general cultivation and the use of by-products. It would be an advantage if he had a working knowledge of the factories and plantations in Java, where the conditions are somewhat similar to those in India.
- (2) An Engineer, for the study of existing installations and the preparation of new models and combinations for *gur* and sugar-making.
- (3) A Chemist for the study of the cane juice and fibre, to conduct ripening tests and manurial experiments, and to assist in the factory work.
- (4) An Agriculturist, whose main duty would be to study the local conditions of soil and climate as affecting the need of irrigation and drainage, the proper times for planting and reaping and the relative period of growth in different tracts.
- (5) A Botanist, for the study of the numerous varieties existing, the transference of varieties from place to place and the raising of new seedling canes for each tract.

Such a Department would, at the outset, be largely engaged in collecting material already existing in the country, so as to gain experience as to the proper lines for work. It should therefore be in close touch, consultatively, with the Provincial Departments of Agriculture interested in the crop, and should be prepared to assist and further any work now being carried on by advice or in any other way. Where local effort is considered insufficient it should inaugurate plantations or experiments on its own initiative, but I would specially desire that local efforts should be encouraged, because the officers on the spot will of necessity have the most reliable first hand information as to the conditions and possibilities of their tract. The work at present being conducted on sugar and the sugarcane is scattered and, for the best results to be obtained, I feel sure that it needs to be organized under one hand.

NOTE ON BURMA AS A SUGARCANE TRACT.

This province has been visited by the Sugarcane Expert for the first time since the above report was written. I find that there are large areas in Upper, Middle and Lower Burma where thick canes can be quite easily grown. I have only met with one indigenous Indian cane and consider it an introduction, from its botanical character, either from Natal or Bihar. There is any amount of uncultivated land available for the growth of sugarcane, so much so that there is no part of India which can for a moment compare with Burma as a possible place for installation of sugar-making factories. Communications are over large areas quite good, much better, in fact, than I had been led to expect. The population is, however, extremely sparse and labour will have to be introduced. The canes grown, although thick, are generally inferior, and I am at once sending over half a dozen good varieties for their replacement. The local Agricultural Department is wholly insufficient as to numbers and fully employed on useful work, and any steps taken will have to be supported by the Government of India. I would suggest the starting of a small sugarcane station, in each of the five tracts which I have studied, for the acclimatization of better kinds and a study of the best methods of growing the canes. Everything connected with the sugarcane in Burma is on an extremely primitive plane, but in almost every place I visited its cultivation is being extended.

(2)

TRAVANCORE.

(N. KUNJAN PILLAI, M.A., B.Sc., Ph.D., *Director of Agriculture.*)

I. HOW TO EXTEND THE AREA.

Travancore is not a large sugarcane-growing country. Sugarcane is now cultivated only on the lands lying by the sides of some of the rivers, and the total area may not exceed 10,000 acres. But there are facilities for the extension of this cultivation. Some of the wet lands in North Travancore and the low lands lying scattered among the hills on the eastern portion of the country can profitably be brought under sugarcane, and arrangements are being made for extending the crop to these areas. In the north more than 50 persons have started sugarcane cultivation under instructions from the Agricultural Department, and the success that they are meeting with will surely induce many more to follow in their footsteps. In the hilly district also several

persons have of late begun sugarcane cultivation, and this year a joint stock company has got registered 1,000 acres, the major portion of which is going to be put under sugarcane. The increase in the price of sugar brought about by the war is opening the eyes of Travancore people to the profits that await them if they only take to sugarcane cultivation, and as a result of the present activities one can look forward to an appreciable increase in the area under sugarcane in the near future. The Agricultural Department is helping the cultivators by giving them instructions and advice and by supplying them with sets of good varieties of canes.

II. HOW TO INCREASE THE YIELD.

The present average yield of *jaggery* in Travancore will hardly be more than two tons per acre. This low yield is due to the defective methods of cultivation, particularly insufficient manuring. The manure that is commonly used for sugarcane, if anything is used at all, is wood ash. The maximum quantity that is applied is not more than 6,000 lb. per acre. A good many cultivators use considerably less than this quantity, while not a few completely dispense with the use of manures. With a view to demonstrate the possibility of increasing the yield of *jaggery* by the use of proper manures the Agricultural Department carried out some experiments during the last two years. The experiments were conducted on one acre plots and the results shown below can therefore be considered reliable.

<i>Manures</i>				<i>Quantity applied per acre</i>	<i>Yield of jaggery per acre</i>
1915—1.	Wood ash	.	.	6,000 lb.	5,520 lb.
	Wood ash	.	.	3,000 "	7,440 "
2.	Oilcake	.	.	1,800 "	
	Fish refuse	.	.	600 "	
1916—1.	Wood ash	.	.	6,000 "	8,160 "
	Wood ash	.	.	3,000 "	7,700 "
2.	Oilcake	.	.	1,800 "	
	Fish refuse	.	.	600 "	

The ash used contained about 1.5 per cent. of potash and 0.75 per cent. of phosphoric acid. The oilcake used was that of *Hydnocarpus Wightiana* and contained 1.5 per cent. of potash, 1.2 per cent. of phosphoric acid and 4 per cent. of nitrogen, and fish refuse contained 5 per cent. of nitrogen and 4 per cent. of phosphoric acid. Thus the ash plot received about 90 lb. of potash and 45 lb. of phosphoric acid, while the other plot received 92 lb. of potash, 67 lb. of phosphoric acid and 102 lb. of nitrogen. It may probably be necessary to vary

the composition of the mixture which can only be done after further experiments. The two experiments described prove clearly the advantages of the mixture over ash. The increase in the yield of *jaggery* was in the one case 1,920 lb. and in the other 1,540 lb., or on an average 1,730 lb. At the present market price of *jaggery* the value of 1,730 lb. is about Rs. 150, and the difference in the price of the manures used was only Rs. 25, the mixture costing Rs. 55 and ash Rs. 30.

It is clear from what has been stated above that by the use of proper manures an acre of sugarcane will yield 3 to $3\frac{1}{2}$ tons of *jaggery*. The average yield at present in Travancore, as already stated, is not more than 2 tons per acre. If all the existing 10,000 acres are cultivated with proper manures the total out-turn of *jaggery* can be increased from 20,000 tons to nearly 35,000 tons. The Agricultural Department is doing all it can to induce the sugarcane cultivators to use the manure mixture which has produced such striking results. The Department has opened this year a manure depôt in an important sugarcane area, and the cultivators in the neighbourhood have purchased manures for nearly Rs. 1,000 in the course of 2 or 3 months. There would have been a much larger sale if arrangements had been made to sell manures on credit and to realize the price during harvest time. If such a system is introduced and manure depôts are opened in other sugarcane areas also, it is possible to make manures widely popular among sugarcane cultivators and thereby bring about a substantial increase in the out-turn of *jaggery* in the country.

11th August, 1917.

(3)

MYSORE.

(L. C. COLEMAN, M.A., PH.D., *Director of Agriculture*.)

I. EXPERIMENTAL WORK.

(a) *Testing varieties.* The results of the past three years have shown conclusively that Red Mauritius cane is a higher yielding variety than any of our local canes. This has been corroborated by nearly all the demonstrations held on private lands. Careful tests on the Hebbal farm indicate that we may anticipate an increase of yield of from 15 to 20 per cent. by the introduction of this variety.

(b) *Manurial tests.* The results of manurial experiments with different quantities of local oilcakes indicate that doses up to two tons of castor cake per acre are very profitable at present prices.

(c) *Spacing tests.* Experiments have shown that the present planting distance for sugarcane (rows 1 ft. to $1\frac{1}{2}$ ft. apart) is too close and that yields at least as good can be obtained by planting twice the distance apart. This is of particular importance in the rapid introduction of new varieties.

(d) *Work on seedling canes.* A large number of seedling canes have been tested and some of these are giving distinct promise. The most promising seedlings are those of White Mauritius, Striped Mauritius, and Red Mauritius. Seedlings are being selected for vigour, purity of juice, and high sucrose content. The weakness of Red Mauritius is the impurity of its juice and its comparatively low sucrose content; its strength is its great vigour. Some of the seedlings obtained from it promise to be just as vigorous as the parent and to yield a very much richer and purer juice.

II. ESTABLISHMENT OF NEW FARMS.

Two new experimental farms which will be devoted largely to sugarcane cultivation have been established within the past two years. One of these is situated under the Marikanave Reservoir where there is an area of about 20,000 acres, 10,000 of which could be devoted profitably to cane. The soil is rather poor and distinctly alkaline, and the work of this farm will have to do with the best means of improving the soil and preventing the increase of alkalinity. The other farm is situated under the new Kannambadi Reservoir where it is anticipated that we shall be able to increase our sugarcane area by 30,000 acres annually. Here the function of the farm will be largely the testing of varieties, the supply of seed, and the demonstration of improved methods of manuring and cultivation. On the former of these farms a power mill is being installed.

III. DEMONSTRATION WORK.

(a) *Introduction of new varieties.* This work has, up to the present, been practically confined to Red Mauritius and an unnamed Java cane. We have been distributing cane in small lots from our central farm for several years, but it has been found that this is an extremely wasteful method as a great many of the sets become damaged in transit. A somewhat novel scheme is therefore being developed for the establishment of a large number of supply centres. Sugarcane sets are supplied

from our farms and are delivered to sugarcane-growers free of charge on the understanding that double the number of sets are returned the following year. These are then distributed under the same conditions the following year. By this method a large number of supply centres are being established and a very rapid introduction of improved varieties will result. As soon as tests on our farms reveal other varieties of outstanding merit they will be distributed in the same way.

(d) *Popularization of the use of oilcakes as manures for sugarcane.* While the best sugarcane-growing districts of the State use oilcakes in large quantities as a manure for cane, in over half our area the use of oilcakes was practically unknown till the Department took up the work of popularizing their use three years ago. The scheme followed is an interesting one. Large quantities of oilcake (about 100 tons) were purchased by the Department and were given out in lots sufficient for one or two acres in areas where the use of oilcake was rare or unknown. Those receiving the cake agreed to pay the cost at the end of their harvest season when the results of the manuring could be seen. The results were almost without exception favourable and the demand for manure increased. During the first two years the manure was advanced without interest, but during the present year interest at 6 per cent. is being charged. As the price of local cakes had increased greatly and as furthermore they were being taken up by local sugarcane-growers, the Department got into touch with oil-pressers outside the State in Bombay and Madras Presidencies with the result that we have been able to obtain our supplies at a much lower rate and at the same time have not in any way disturbed the local supplies. During the past year about 300 tons of groundnut and safflower cake, two cakes which have been practically unknown to Mysore sugarcane-growers and which are much richer than our local cakes, have been distributed. A scheme is being developed for the crushing of the large supplies of oil-seeds (chiefly castor and groundnut) which are now being shipped out of the State. It is proposed to erect a large oil-seed-crushing plant under the control of the Department of Industries and Commerce, the Department of Agriculture to take over the distribution and sale of the cake in new areas. The scheme contemplates the production of between 1,000 and 2,000 tons of cake per annum. If the scheme is successful similar plants are certain to be established by private agency, and it may perhaps not be too sanguine to anticipate that within the next ten years we shall find the bulk of the oil-seeds which are now being exported utilized in the State.

October, 1917.

(4)

BOMBAY.

(a)

(J. B. KNIGHT, M.Sc., B.Sc., *Professor of Agriculture, Poona.*)

I. AGRICULTURAL ASPECT.

Most of the work with cane has been along the lines already put before the Board in the year 1916, by Rao Bahadur G. K. Kelkar, the then acting Professor of Agriculture.¹

Manjri farm was the first centre for experimentation and demonstration of better methods with this crop. Later work was undertaken in Satara and Nasik. The use of concentrates and better furnaces being the main lines, district work has steadily spread and now includes all the cane-growing tracts. In the district, besides demonstrating the results of Manjri, special problems of local importance have been taken up. The principal centres of this work are Kasundra, Ahmedabad District, where improvement in *gur* manufacture and white-ant attack were the problems. Here the Manjri methods of *gur* manufacture have been successfully introduced. At Amalsad, Surat District, the question was of red-rot. At Kopergaon the work has taken the line of introducing improved methods of cultivation and manufacture, also the best way to deal with this crop on peculiar types of soil. In Nasik the improvement in manufacturing methods has been steadily pushed. The old type of furnace is nearly extinct. Crushing is being improved by means of establishing co-operative power crushing plants. In Satara, Belgaum and Dharwar, the improved furnaces are increasing. In Nira and Mutha valleys, near Sholapur, in small areas in Belgaum, Dharwar and Satara, the spreading of the new Manjri method as outlined in Rao Bahadur Kelkar's note referred to above has proceeded. In the districts of Nasik, Ahmednagar, Satara and Belgaum, sulphate of ammonia has been found very useful as a cane manure and its use is rapidly spreading.

Iron mills have now become practically universal. The Nahan, Alcock and Chattanooga No. 33 are the new types that are giving satisfaction and gaining popularity. The Alcock was devised in consultation with the Manjri farm staff.

Two hundred lots of canes from Bombay cane-growing tracts have been brought together at the Manjri farm. The seed has been

¹ *Proceedings of the Board of Agriculture in India, 1916, p. 94.*

increased and those which are obviously of the same variety have been grouped together. Analyses have been made and sub-groups established on the composition basis. Manner of growth, earliness, etc., have been noted. The special adaptation of each group as to soil, climate, and methods of cultivation, is being studied. About sixty varieties from other provinces and outside India have been obtained and grown at Manjri. Five varieties have been grown on a scale for obtaining yield figures. These appear to be useful for tracts where the growing season is short on account of their earliness. These are known at the farm as Red Sports, Striped Mauritius, and J. 36 M. These are nearly equal to Pundia, in yield and richness. Two other varieties, Green and Red Mauritius, are proving useful as 18 months crops.

II. CULTIVATION.

Several methods of growing cane are under experimentation, including Java, West Indies, Mauritius, modified Java, modified West Indies, and Manjri farm methods; results are yet to come. Seed rate and tillage are also under study. It is certain that a lower seed rate is practical.

Observations of cane fields at different places under ordinary and careful methods show that a number of the tillers sprouting from sets do not form mature canes at all or form only very small ones. With a large number of sets, viz., from twelve to eighteen thousand, having three or four eye-buds in each and a large number of tillers from each, the present yield of cane is only about 25,000 in number weighing about 80,000 lb. To avoid this waste Rao Saheb Kulkarni, Acting Deputy Director of Agriculture, Southern Division, is experimenting with single eye-bud plants, and his standing crop is very promising. The question of transplanting of young plants from one eye-bud is also being investigated by him.

III. MANURE.

San (*Crotalaria juncea*) as a green manure has been demonstrated to be the most economical coarse manure. On the Kopergaon canals a method of growing the *san* with the crop and burying at earthing up, is gaining ground. Stable manure has proved superior to farmyard manure.

September, 1917.

(b)

THE HON'BLE MR. G. F. KEATINGE, C.I.E., I.C.S., *Director of Agriculture, Bombay.*)

* * *

SUGAR.

To the extent of its irrigation facilities the Deccan has admirable facilities for sugar production. At present these irrigation facilities are very limited, and the sugarcane crop grown on the water allotted to it is worked up into *gur* or raw sugar consisting of all the solid contents of the cane juice. Some cultivators grow excellent cane, and the industry so far as it goes is a profitable one, but the average production of cane is much lower than it should be, and the losses that occur in the manufacture of *gur* by primitive methods are large. It has now been decided steadily to increase the area under canal irrigation in the Deccan, and a large programme has been drawn up. The following canals will increase the area under sugarcane by about the acreage mentioned against them, *viz.*, Godavari canals (just completed), 12,000 acres; Pravara canals (almost ready), 12,000 acres; Nira Right Bank canal (under construction), 20,000 acres; and Gokak canal (sanctioned), 20,000 acres. Total 64,000 acres. There are many other canals to follow. As these new canals are opened, and as cane growing increases it is probable that if all the produce is made into *gur* there will be a glut of *gur* for local consumption and possibly a disastrous fall in price. The manufacture of sugar will then become necessary. In order that sugar factories may be started they must be able effectively to control a certain area of land on which they can grow a large part of their own cane, and this area must be compact, so as to allow cheap and rapid transport of cane to the factory. This involves the crux of the situation, since the land is at present occupied in small lots by the very large number of landholders, and it is not possible for a projected company to obtain a large block of land on a secure tenure. I believe that (here is only one way in which this difficulty can be overcome without injustice to the present occupants, and this would involve legislation. The plan would be this. When the alignment of a new canal is settled and it is decided to allot perennial water to a definite area (say 20,000 acres), the area to which perennial irrigation can be best applied should be settled by a survey. The holdings in this area should then be pooled and squared, each cultivator receiving (say) three-fourths of the area which he held before, with water rights attached, and the remaining one-fourth should be retained

by Government for assignment preferably on a long lease, to a sugar company. This area would be in one block and would enable a sugar company to get to work under optimum conditions. A cultivator who formerly had 20 acres of dry crop land in a region of precarious rainfall would now have 15 acres with water rights attached, and would be in a much better position than he was before. In this way a profitable sugar industry might be created and the future of the Deccan canals assured. Incidentally the arrangement would greatly improve irrigation practices, check damage to the land from over-irrigation and enable the land under the canal to be developed in an orderly and businesslike fashion, to the great advantage of the cultivators and the public.*

(5)

CENTRAL PROVINCES.

(D. CLOUSTON, M.A., B.Sc., *Officiating Director of Agriculture.*)

All the cane grown in the Central Provinces is used either for chewing or for *gur*-making. The varieties in demand for chewing are thick soft canes like Pounda and Ashy Mauritius. Mr. McGlashan, who started cane cultivation in the Chanda District some years ago with the view of establishing a factory for the manufacture of white sugar, has not yet been able to make a beginning, owing to the difficulty of procuring machinery from home.

A large number of improved cane mills have been introduced in the provinces within the last 10 years. In Chanda District alone, over 300 Sultan mills, costing at present Rs. 140 each, have been sold by the Department. Considerable progress has also been made in introducing the improved furnace for *gur*-making. The cost of manufacturing *gur* by this—the Poona furnace—is thereby being reduced very considerably, as it is no longer necessary to purchase wood for fuel. Owing to the difficulty experienced in finding sufficient draught power to crush any considerable quantity of cane on an average holding, cane-growers are loth to increase their cane areas to any great extent. The introduction of small power cane mills, capable of crushing from 5 to 10 tons per day, would appear to be the most practical way of solving the difficulty. The Department has two such plants on the Sindewahi farm, one of which is being hired out to cane-growers in the neighbourhood.

Much attention has been given to the study of indigenous and exotic canes both from an agricultural and a chemical aspect. Of the numerous varieties which have been tested within the last 10 years,

* Extract from the Evidence given before the Indian Industrial Commission.

the best results have been obtained up to date from Sunnabille, Khari, Java 247, Yuba, Ashy Mauritius, and Red Mauritius, all of which have been introduced by the Department. Sunnabille, obtained 10 years ago from Bombay, has in parts of the Southern Circle largely ousted the thin reed-like local cane known as Katai. Khari and Java 247 are also being grown very successfully. The former has now been under trial as a ratoon crop on the Telinkheri farm for 7 years. As a ratooner it is second to none. This particular variety, tried for the first time on the Telinkheri farm 8 years ago, has since been grown most successfully both in the Northern and Southern Circles. Like Java 247, Sunnabille and Yuba, it does equally well on heavy black clayey loams and on the thin lateritic soil of the *bhata* plains of Chhattisgarh. Of the thick canes under trial Ashy Mauritius is perhaps the most promising. Seed of this variety has been supplied to cultivators in considerable quantities. Java 247 is the hardest of all the varieties tried, and for that reason we recommend it as a cane suitable for villages where wild pigs damage the softer canes. It is evident from the experiments carried out by the Department that under the conditions prevailing in the average village, the cultivation of canes like Java 247, Sunnabille, and Khari pays much better than that of the thicker and softer varieties. Efforts are therefore being made to extend the cultivation of these harder and harder canes. Over 4 lakhs of canes of the three varieties named above were supplied to cultivators last year for seed purposes.

Experiments to ascertain the best method of cultivating cane have shown that whereas the trench or Java method gives as a rule the larger out-turns, it requires at the same time much more labour for the digging of the trenches by hand, and labour is difficult to procure in most districts during the planting season. The furrow system, by which the land is ridged by means of a furrow plough drawn by a pair of bullocks, is much cheaper and more expeditious than the Java system. The Delta plough is being used on Government farms not only for making the furrows but also for earthing up the cane later. By using this plough and the Planet Junior hoe for cultivating cane the cost is much reduced.

Irrigation and manurial experiments are being carried out on black clayey loam, on lighter sandy loams, and on gravelly lateritic soils. The manuring of cane with cattle-dung or *san* hemp, followed by a top-dressing of cake, has been found to be the most profitable system for adoption on a large scale, though sheep-folding pays better where sheep are available. From results already obtained from experiments lately started on some of the Government farms, it would appear that our soils are deficient not only in nitrogen but also in phosphates, and that

the application of superphosphate adds largely to the acreage out-turn of cane. The manuring of cane with *san* hemp has been adopted as a regular practice on some of the Government farms, and a few cultivators have already begun to follow our example.

The production of refined sugar is not a question of any practical importance in the Central Provinces at the present time. The attempt made 8 years ago to manufacture white sugar by the Hadi process proved a failure. The Department, however, is devoting much attention to ways and means of improving the quality of *gur*. That produced on Government farms is sold locally at $4\frac{1}{2}$ to 6 seers per rupee when the price of the United Provinces *gur* in the bazaar is 8 seers per rupee. The area under cane in the Central Provinces has declined very much within the last 20 years owing to various causes, the chief of which have been the cost of irrigation, the cost of fuel, and the difficulty of protecting the crop from wild pig. An extension of the area under cane may be expected under the larger Government irrigation works, more especially under the Mahanadi and Tendula canals which are now nearing completion in Chhattisgarh. Under these canals there are very large stretches of waste land known as *bhata*, a lateritic soil which has been found on the Chandkhuri farm to be specially suitable for cane-growing.

The improved furnace which the Department is getting cane-growers to use meets the fuel difficulty. To get rid of wild pig, pig-killing clubs have been formed in some parts of the provinces, while in other parts the crop is being fenced with patent pig-proof fencing which the Department of Agriculture keeps in stock at some of its implement depôts.

August, 1917.

(6)

BENGAL.

(R. S. FINLOW, B.Sc., F.I.C., F.C.S., *Officiating Agricultural Chemist.*)

I. EXPERIMENTS AT Dacca.

(a) *Investigation into local canes.* In the last report on sugarcane in Bengal written in 1916, the commencement at Dacca of the work of classifying the local sugarcanes of Bengal was described.¹

This work has been carried on since Mr. Annett's departure. Weather conditions in the season 1916-17 and also in 1917-18 have been very unfortunate as far as the red soil of the Dacca farm is concerned; nevertheless considerable progress has been made.

¹ *Proceedings of the Board of Agriculture in India, 1916*, p. 89.

Briefly, the object has been to grow the local canes side by side with the best exotic varieties and to compare the respective varieties both as regards their yields of cane per acre and also the sucrose content of the cane juice.

It was mentioned in the last progress report that there was some uncertainty regarding the identity of the varieties sent in from the district and, on the advice of Dr. Barber, who inspected the plots in the cold weather of 1915-16, a new set of specimens was arranged for. These were planted in Mastul field in 1916.

The varieties were distributed as follows :—

From—				
Dacca District	.	.	.	13
Pabna	.	.	.	1
Mymensingh	.	.	.	9
Birdwan	.	.	.	6
24 Parganas	.	.	.	1
Rajshahi	.	.	.	2
Backerganj	.	.	.	3
Faridpur	.	.	.	5
Chittagong	.	.	.	3
Murshidabad	.	.	.	1

In addition, there was one cane each from the United Provinces and the Central Provinces respectively, besides five Bengal varieties of which the origin is uncertain. There were also 9 exotic canes.

All these varieties were grown at Dacca in 1916-17 and 1917-18. There were obviously too many to allow of a sufficient area of each to be planted to enable a *gur*-making test to be made, and selection has therefore been based on analytical figures and on personal inspection of each variety. Fourteen varieties have been provisionally selected in this way for more detailed investigation.

Where sufficient sets are available the selected canes will be tested in the present season for their yield of *gur* as well as in regard to their purity of juice and yield of cane per acre. In several cases, however, further multiplication will be necessary before this can be done.

In selecting the canes, the very different conditions which exist in various parts of the province of Bengal have to be borne in mind. For instance, Rajshahi is somewhat similar to Bihar but with a better rainfall. In Faridpur and in several other tracts the sugarcane crop has to exist for a considerable portion of its period of growth in land which, excepting in the first month or two, is probably always water-logged, and very often inundated to a depth of one or even two feet. In the red soil tracts of Dacca and Mymensingh, on the other hand, the crop has to withstand almost arid conditions in the latter portion of the season.

It is conceivable therefore that a cane which will suit one tract in the province may not do for another, and until this point is settled it will be necessary to retain the best types of cane grown in the respective tracts.

(b) *Exotic varieties.* Of these, Yellow Tanna and J. 247 are the canes which seem to withstand the conditions at Dacca best : but it must not be forgotten that the last two seasons have been entirely unfavourable. This has been chiefly due to prolonged droughts in the early part of each season : thus only the most vigorous canes were able to establish themselves. Dacca Gandari, which with 4,240 lb. of *gur* per acre was practically equal to J. 247 in 1916-17, did not improve in 1918, whereas J. 247 yielded 6,000 lb. of *gur* per acre on duplicate plots.

In another year, like the present, 1918-19, which has been decidedly favourable so far, the more delicate races may well come to the front. When B. 147 and B. 208 were first introduced into Dacca by Mr. Meggitt, yields approximating to 120 maunds of *gur* per acre were obtained. But, however well a race may do in good years, it is a very great disadvantage if it is unable to withstand adverse conditions, and it is a matter for discussion whether the Department should ever attempt to introduce the cultivation of such a cane on a large scale. This is especially the case if another race is at hand which is hardy, even if its yielding capacity is not quite so great. Looked at in this way, a bad year is often by no means wholly unfortunate from the point of view of the investigator.

During the last two or three years there has been a good deal of disease at Dacca and, at the commencement of the present season, it was decided to select rigidly the canes which were to be used as sets. Each of these canes was examined and passed by the Entomological and Mycological Collectors, and it is probable that the greatly improved appearance of the cane this year is due partly to the care thus exercised, as well as to a favourable season. The selection will be systematically pursued each year in future.

II. SUGARCANE EXPERIMENTS AT OTHER STATIONS IN BENGAL.

(a) *Rangpur.* The following races have been grown at the Rangpur Dairy Farm in the last two years:—

Variety	Yields of <i>gur</i> per acre	
	1916-17	1917-18
	lb.	lb.
Yellow Tanna	4,600	4,620
Vendamukhi (Rajshahi)	2,760	3,299
B. 147	4,400	4,440
Samsara (Burdwan)	1,500	2,824
Striped Tanna	2,950	4,520
Dacca Gandari	5,400	5,720
Khazri (Local) . . . . .	..	2,820

Thus at Rangpur, though none of the returns are very high, Dacca Gandari has proved the most satisfactory yielder in both years, Yellow Tanna being second best in both years.

At the Rangpur Demonstration Farm, Dacca Gandari, with 67 maunds of *gur* per acre, was the best yielder in 1916-17, while in 1917-18 Gandari, B. 3412 and Red Mauritius were all close together with 5,120, 5,480 and 4,800 lb. per acre respectively.

It is proposed to introduce J. 247 into Rangpur in the next season, 1919-20.

(b) *Chinsurah*. The season 1916-17 was an unfavourable one, partly on account of drought, and partly because of a heavy cyclone in September 1917, which did considerable damage. Nevertheless some of the canes did well.

In 1917-18 the crop was a good one and some very high yields of *gur* were recorded.

Variety	Average outturn of <i>gur</i> per acre	
	1916-17	1917-18
	lb.	lb.
Yellow Tanna	8,241	8,400
B. 147	6,052	7,520
B. 208	4,067	5,304
Red Mauritius	6,244	9,160
B. 3412	5,976	8,320
Striped Tanna	4,006	9,020
Samsara (Burdwan)	3,892	8,198
Dacca Gandari	3,436	6,518
Puri (Burdwan)	3,104	..
Vendamukhi (Rajshahi) . . . . .	..	7,148
Khari (Burdwan) . . . . .	..	7,365

Yellow Tanna stands first on the average; but Dacca Gandari is apparently not so much at home at Chinsurah as at Dacca and Rangpur. On the whole the more favourable conditions at Chinsurah are reflected, as at Rangpur, in considerably higher yields from the more delicate varieties.

(c) *Rajshahi*. The following varieties have been grown at Rajshahi in 1915-16, 1916-17, and 1917-18. The results for 1916-17 are not given. Moisture was very poor in that year and germination of the sets was so bad as to make the results unreliable :—

Variety	Weight of <i>gur</i> per acre			REMARKS applying to the 1917-18 crop.
	1915-16	1916-17	1917-18	
	lb.		lb.	
Vendamukhi (Local) . .	9,030	..	8,540	Lodged.
Puri (Local)	6,460	..	..
Striped Tanna	8,870	..	10,606	Stood erect.
Yellow Tanna	8,860	..	11,352	Do.
B. 147	8,330	..	7,960	Blown down.
Dacca Gandari . . . .	..	..	4,196	Blown down and greater portion damaged by wild animals.

As at Chinsurah the Tanna varieties gave the best yield in 1917. This was probably partly due to their sturdy capacity for withstanding rough weather and partly to their being able to resist attack from jackal and pigs. This latter is a particularly valuable property in a district like Rajshahi where wild animals generally are more than usually common.

III. GENERAL REMARKS.

The conclusions to be drawn from the experiments recorded above are that at three out of four experiment stations in Bengal, an exotic race generally leads the way in the matter of yield as compared with local varieties.

On the other hand, at Dacca, Chinsurah and Rangpur, there are local canes, namely, Gandari, Samsara, and Vendamukhi respectively, which if not equal to the best exotic are still capable of profitable cultivation.

It would appear that in most cases exotic canes are not capable of retaining their good qualities indefinitely; but as far as Bengal is concerned Yellow Tanna seems to be an exception. It has been grown in the province for many years now, and while still on the average one of the best, if not actually the best, *gur*-making canes it is also probably the most robust variety. Noel Deerr states ("Cane Sugar", page 29) that "generally speaking they (Tanna varieties) are deep rooters and suffer only to a limited extent from the effects of drought." This might

have been written from experience with Yellow Tanna on the red soils at Dacca.

A second cane has shown great vigour at Dacca in the last two years. This is J. 247 which, while tillering freely, and growing to a great height, appears to resemble Yellow Tanna in its drought-resisting properties. Sufficient sets of J. 247 will be available next season for extended tests at each of the four experimental stations in the province.

Both Yellow Tanna and J. 247 appear to be canes whose juice is only of moderate purity. Therefore, while excellent as far as *gur*-making is concerned, they might be at a disadvantage as compared with some other canes when white sugar is the object.

27th May, 1918.

(7)

BIHAR AND ORISSA.

(G. MILNE, I.C.S., *Director of Agriculture.*)

The scheme for the establishment of a sugarcane station in North Bihar, which had been approved by Government but postponed on account of the financial stringency and also of the difficulty of getting factory *zirats* owing to the revival of the indigo industry, was subjected to further examination in the light of the recommendations of the last Board of Agriculture. A site has been provisionally selected in the district of Darbhanga and, if it proves to be satisfactory on further inspection during the rains, a detailed scheme for the establishment of the station will be submitted to Government.

In the meantime some work is being done at Sipaya and Sabour.

On the Sipaya farm sixty varieties of sugarcane, of which 54 were obtained from various quarters of the province and 6 from Queensland, Australia, have been under cultivation, the area at present occupied by the former being 5.10 acres and by the latter 2.18 acres. All the varieties except one have been analysed for sugar content under the direction of Mr. C. S. Taylor, Agricultural Chemist to Government, and a record has been kept of the analysis made.

On the Sabour farm the work has been limited to the best method of growing the cane, and it has been proved that the trenching method generally adopted in Mauritius is suitable to the conditions of Bihar, as it provides for irrigation and for draining the surface water of the land in the rainy season.

On the mechanical side, Banerji's sugarcane-crushing mills and iron evaporating pans for *gur*-boiling have been found to be superior to local ones and are being recommended to the cultivators.

On the botanical side, the varieties of sugarcane isolated at Sabour by selection have been cultivated in pure culture.

The Mungo variety of sugarcane and the ridge and furrow system of cultivating it have been extended in parts of Cuttack and Puri districts. The improved method of *gur*-making by the shallow evaporating pan has also been introduced in these and other areas; the *gur* thus manufactured from the Mungo variety fetched Rs. 2 more per maund ($82\frac{2}{7}$ lb.) than the *gur* made by the local method.

September, 1917.

(8)

UNITED PROVINCES.

(THE HON'BLE MR. H. R. C. HAILEY, C.I.E., I.C.S., *Director, Department of Land Records and Agriculture.*)

As this is the last year in which Mr. Hulme will have an opportunity of attending the Board of Agriculture, he has put up a full note on the working of the experimental factory at Nawabganj and enclosed illustrations of the plant employed.¹ At the last meeting of the Board it was suggested that arrangements should be made for a more adequate supply of cane to the factory. Mainly owing to the extremely bad crop in the neighbourhood, this was impossible last season, but advances have been given this year to cultivators, which should, provided the crop is a normal one, secure a future supply. As regards the question of the progress made since the last meeting, it must be pointed out that since that date it has been practically impossible to obtain sugar-making machinery of any description, and therefore any development on the manufacturing side has been out of question. In addition to this, the price of *gur* has risen considerably and there has been a greater tendency to look to *gur*-making than to sugar as a profitable business. It may, however, be mentioned that the two sugar factories in these provinces that have in different ways received assistance from Government, namely, those at Pilibhit and Tamkahi, are now in full working order and it is understood that they had successful seasons. The latter last season turned out

¹ *Pusa Agri. Res. Inst. Bull.* no. 82.

close on 3,000 tons of sugar. As to future developments on the manufacturing side, some of the larger growers in these provinces, particularly owners of private farms, are contemplating putting down *gur*-making factories as soon as plant is available, and a number of communications have been received regarding their instalment. It is clear that the absolute necessity for using mechanical power for crushing, if cane is grown on at all a large scale, is now more fully realized, and it is believed that there will be a good demand for power crushing plant as soon as the machinery is available. Assistance was given by the Agricultural Adviser in demonstrating a small power crushing plant, and a certain number of mills made in the country or imported from America are in use. It is probable, however, that though suitable for cultivators working with oil engines, a larger type will be required for *gur* factories.

On the cultural side the work at the research farm has been continued on the lines previously indicated. Attention had mainly been devoted to putting out some of the varieties found most suitable at the Shahjahanpur station and to improving methods of cultivation generally by demonstration work. A considerable number of demonstrations have been given and opportunity has been taken to distribute gratis cake manures with a view to their popularization. The Department in this respect has received considerable assistance from the cane factories at Rosa and Tamkahi and from the owners of private farms who have begun the cultivation of cane on a large scale. Some of these private farms have followed the methods of cultivation recommended by Mr. Clarke with considerable success and have effected marked improvement in yields of *gur*. The main work of the Department is concentrated on teaching the people better methods of planting and cultivation, and it is believed that when these are more generally in force the introduction of better classes of cane will necessarily follow; but, until adopted, the best results will not be obtained from the work at the research farm in these provinces or that at Coimbatore.

October, 1917.

(9)

PUNJAB.

(C. A. H. TOWNSEND, I.C.S., *Director of Agriculture and Industries.*)

The late Mr. Barnes wrote three progress reports on sugar in the Punjab. The reports for 1911-12 and 1912-13 have been printed:

the third, which covers the progress made after 1913, is in the press, under the supervision of the Agricultural Adviser to the Government of India.¹ A perusal of these reports will show that the survey and analysis of the principal canes grown in the Gurdaspur District and on the experimental farm there has been completed. The experimental and varietal testing of canes on the farm, commenced in 1912, is still in progress. No cultural experiments have as yet been instituted: manurial experiments with artificial manures have recently been commenced.

The results arrived at so far are as follows:—

The Punjab as a whole is ill-suited, on account of its cold winter, to canes, and the crop can never become really popular in the province. A proposal to start a small sugarcane farm in the Karnal or Gurgaon District, in the south-east of the province, where the climatic conditions are much more suited to cane than the more northerly parts of the province, and where the yields per acre are very much greater, is under consideration.

As to varietal tests, a commencement was made in 1912 with some 40 varieties, both indigenous and exotic, thick and thin. All these came from India: to them were added in 1915 an Egyptian cane, J. 105, brought by Mr. Barnes himself from Egypt, and J. 33, a Java cane.

Nearly all the thick varieties have been discarded; a few of the more promising ones are still under trial, and will be transferred to the new station in the south-east of the province, if and when it is formed. J. 105 and J. 33 have done fairly well on the farm, and are expected to do well in the Karnal District where they have been given for trial this year. These are medium thick canes.

Of the thinner varieties some twelve are still under trial at the Gurdaspur farm: five of these—Sonabli, Behar, Suretha, Mungo and Dhaura of Azamgarh—have given almost always good results. They were given out to zemindars last year in the Gurdaspur District, and were well reported on. They are being again grown this year: of these Behar and Sonabli appear the best.

Yuba is another cane recently obtained from the United Provinces, and still under trial. It is giving promising results.

Mungo and Dhaura of Azamgarh are well suited to low-lying *bet* (riverain) lands: the latter gave as much as 60 maunds of *gur* per acre. This was grown without any artificial irrigation.

Some sugarcane work, both varietal and manurial, is also being conducted at Lyallpur and Hansi: but it is not, as yet, very important.

August, 1917.

¹ "Suzar and the Sugarcane in the Gurdaspur District." *Pusa Agri. Res. Inst. Bull.* no. 69.

(10)

NORTH-WEST FRONTIER PROVINCE.

(W. ROBERTSON BROWN, *Agricultural Officer.*)

I. SUGARCANE.

Climate of the Peshawar valley. It is sometimes stated that the Punjab and the North-West Frontier Province are outside India's sugarcane belt. To understand, therefore, how on 25,000 acres of land such a high weight per acre of cane, fairly good in quality, is annually produced at Peshawar, it is necessary to know something of the climate and environment of that part of the valley where most of the cane is grown. Four seasons are recognized at Peshawar.

Spring in February, March, and April. During the earlier part of this period there are occasional light hail-storms, and usually rain falls to the extent of three or four inches. Cane is planted about the 15th March. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
February	65.7	42.5	54.1
March	75.0	51.7	63.3
April	85.5	60.3	72.9

Summer comes in May, June and July. Rain rarely falls during this season, which is the hottest of the year. It is frequently dense hazy, and dust storms occur in June and July. In this season the young cane plants become established. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
May	98.1	69.9	84.0
June	105.9	77.3	91.6
July	102.7	79.2	90.9

Autumn comes in August, September and October. The season is ushered in by the hot weather rains. They break over the valley in four or five violent storms at intervals of a few days, and two or three inches of rain fall on each occasion. During the first part of this season the sky is more or less uniformly overcast with clouds, and the air is steamy and oppressive. The growth of the cane is extraordinarily rapid during this season. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
August	99.2	78.0	88.6
September	95.3	70.5	83.1
October	88.2	57.9	73.1

Winter comes in November, December and January. During this season the weather is variable. The sky is at first hazy, then cloudy, with sometimes slight rain. There is a remarkable absence of wind generally and the air is still and stagnant. The first touch of frost is expected towards the end of November, and the sugarcane then ceases to grow. Normals of temperature derived from the data of 33 years are as follow :—

Month	Normal maximum temperature	Normal minimum temperature	Normal mean temperature
November	77.3	46.1	61.7
December	67.0	39.2	53.1
January	63.0	30.6	51.3

The plant-cane is fully established and well away by the 15th June ; in July the crop is earthed up ; in August, September, and October the cane lengthens and gains in weight very rapidly (owing to its exceedingly rapid growth, the Peshawar cane has very long internodes and, in consequence, exceptionally high juice percentage). In November the cane begins to ripen and with the first touch of frost the cultivators start cutting the crop.

Cultivation. The method of growing cane in Peshawar District is probably unique in the production of the crop, and it is certainly one of

the cheapest and most efficient practised anywhere. On the 15th September a clover (*Trifolium resupinatum*) is broadcasted over the level land. The resultant crop is cut for stock in November, again in January, and in early March. Then the area is lightly furrowed or marked by the country plough at intervals of about three feet and the sugarcane sets are laid end to end in these shallow drills without any covering of soil. The area is next irrigated. In a few days' time the clover grows up and covers the cane sets, and these quickly put forth roots and send out shoots through the clover. In April the clover is again cut and laid alongside the growing cane, there to rot and enrich the soil. In May the lines of cane are lightly hoed, some manure is applied to the plants, and the lines are inter-cultivated by the country plough. Later cultivation consists of weeding, inter-tillage, and irrigation until late July, when the lengthening cane is substantially earthed up. After this nothing further but generous irrigation is given till the crop ripens in December. No tying-up or protection from jackal or pig is necessary at Peshawar. After many trials of other better known methods of cultivation, no practice has been found so simple, so cheap and efficient as that which the Peshawar growers have followed for a quarter of a century.

Cost of cultivation. Under the method described in the preceding paragraph, crops of from 25 to 30 tons of cane per acre are usually produced by the cultivators at a cost of Rs. 4 to Rs. 5 per ton. This price includes rent, revenue, and all other charges. After many trials and experiments the Peshawar Agricultural Station has not succeeded in growing sugarcane more cheaply than the Pathans, who have followed their simple method for many years.

Irrigation. The total average annual rainfall of the Peshawar District is only 13 inches, but a very large part of the valley's cane is grown on the banks of the Kabul river where the cultivators generally can have as much water as they desire from the canals which are maintained by themselves. The method of applying the water is rather wasteful but it is simple and efficient. The sugarcane-growers realize that the cane is built up by almost unlimited supplies of water in late September and October, provided this is associated with efficient drainage. They also know that no water should be supplied within 14 days of the date when the crushing of the cane begins. The irrigation of cane is quite well understood by the Peshawar cultivators.

Rotations. Clover, sugarcane, maize, wheat, clover, and so on is the most favoured rotation on the banks of the Kabul river, and no more suitable or profitable rotation has been found at the Peshawar Agricultural Station.

Implements employed in the cultivation of sugarcane. The steel inversion plough is successfully employed at the Peshawar Agricultural Station in uprooting sugarcane stumps, and to ensure deep tillage, but the cane-growers have not shown any inclination to take up the plough. They very reasonably point out that an inversion plough upsets the levels of their fields and is liable to entail more work and expense in re-adjusting the levels than is warranted by the increased yield of cane. There is no call for improved implements in the cultivation of sugarcane at Peshawar at present.

Harvesting sugarcane. Trans-border men and women cut the Peshawar cane for the cultivators, and in payment of their labour receive the cane tops that would otherwise rot on the land. An agricultural station need not seek a cheaper method of harvesting sugarcane than this.

Insects and diseases. Sugarcane-borers spoil a considerable part of the Peshawar cane crop, but the pests are perhaps not more troublesome in the North-West Frontier Province than in any country where cane is grown. The Pathans contend that cane which is planted in *skhtal* for a time entirely escapes the attacks of the cane-borers, and this belief has been very well confirmed at the Peshawar Agricultural Station. After a fallow, on the other hand, the young cane plants frequently suffer severely from borers, and it has been demonstrated at Tarnab that it is then profitable to collect the egg-clusters of the pests from the young canes.

Red-rot is present wherever cane is grown in the North-West Frontier Province, but the disease is not a seriously destructive one at the present time on the banks of the Kabul river. The cultivators know well that they can check the spread of the disease by discarding disease-affected cane sets when they plant their fields in March. The diseased cane is discarded very unwillingly, however, for cane seed costs from 6 to 12 annas per maund in March, after it has been preserved in clamps for two or three months. It is a remarkable fact that the thick cane that is now grown at Peshawar has been cultivated there to the entire exclusion of any other variety for over half a century.

Tests of varieties. After testing numerous varieties at Tarnab, the variety named D. 74, which is so extensively grown and so highly valued by the cane planters of Louisiana, is the only one that has rivalled the Peshawar cane in all-round merit. This Demerara seedling ripens earlier than the Peshawar variety, which it otherwise closely resembles. In a series of analyses that were carried out at Peshawar over a period of four years by Dr. Leather, it was determined that the Peshawar cane contains a high proportion of juice, with from 12 to 14 per cent. sucrose,

and that the cane is at its best in January. Treated in a bullock power Nahan mill in this month, the cane yields about 75 per cent. juice, and this contains about 13 per cent. sucrose, 1.5 per cent. glucose, and has a purity co-efficient of about 80.

Gur. The Poona method of making *gur*, that is frequently recommended and very well spoken of in South India, was tried at Peshawar in 1912, and found no more efficient and far more troublesome and cumbrous, and certainly more expensive, than the more adaptable Peshawar method. As the best Peshawar *gur* realizes a price second to none in India, the Pathan's method of *gur*-boiling appears to be satisfactory.

Cost of gur-boiling. The cost of making *gur* and placing it on the market is fully 60 per cent. of the cost of producing the cane. *Gur*, it has been found at the Peshawar Agricultural Station, can be made at a profit only where the young members of a family, the boys and girls, and women assist in making the sugar. *Gur*-boiling is not very profitable when stalwart men are hired to drive the bullocks, to feed the mill, to carry the juice, to make the *gur* balls, etc. The growers of large areas of cane, indeed say they would rather sell their cane than convert it into *gur*, if they could get a fair price for the crop.

Co-operative gur-boiling. In those North-West Frontier villages where sugarcane is an important crop, small groups or families of growers invariably co-operate in making *gur*, and this arrangement is satisfactory. In experiments that have been carried out elsewhere in India, it does not appear that *gur* can be satisfactorily and profitably made in a large factory, so there is no call at present to attempt to alter the Pathans' method of producing *gur*. At Peshawar, as elsewhere, *gur* will probably always be produced chiefly by the growers of small, isolated areas of cane. Where large blocks of cane can be grown in the North-West Frontier Province the growers state that they would prefer to sell their cane to a factory rather than convert it into *gur*, but some few cultivators, it has been observed, would like as much for their cane as they realize for this when it is converted into *gur*.

Length of the sugarcane-crushing season. On the banks of the Kabul river, where the sugarcane of Peshawar grows best and ripens earliest, *gur*-boiling begins on the 20th November or even earlier than this and proceeds busily till the middle of February. The average length of the *gur*-boiling season is 100 days. But experiments at the Agricultural Station have clearly shown that the cane-crushing season may be extended to 130 days without any loss of sugar if the crop is windrowed after rain falls in March. It also appears from the experiments that cane continues to ripen satisfactorily after the buds of the cane are killed.

by frost in December, and that the cane in this state remains sound for two or even three months at Peshawar.

Potentialities in the production of refined sugar from cane at Peshawar. About 2,500 tons of refined sugar are annually imported to Peshawar by rail, and a large part of this is again exported, chiefly by way of the frontier passes from Peshawar. Most of the refined sugar comes to India from across the seas. By reason of its position, more than 1,000 miles from a seaport, Peshawar may always enjoy a considerable measure of protection for any refined sugar it produces. On the other hand, the price of coal and other imported commodities must always be greater at Peshawar than elsewhere in India where sugar is now produced.

It has been determined that the Peshawar cane is of good manufacturing quality; that the cane is cheap; that it is produced on compact areas; that the facilities for transport, especially by water, are most exceptionally favourable at Peshawar; that the landholders desire to grow cane more extensively than they do at present, and they wish to sell the cane rather than to convert it into *gur*. A demand exists in the numerous cantonments of the frontier for a large quantity of rum which is now imported, and it would even be possible to use molasses in the preparation of service rations for artillery and cavalry animals, and for the animals of the Supply and Transport units. All these questions are being investigated, with the help of the expert officers of the Agricultural Research Institute at Pusa, by the Department of Agriculture in the North-West Frontier Province, and there is reason to hope that a sugar factory will be established on the Kabul river before very long.

II. SUGAR-BEET.

When experiments began at Tarnab in 1911, to find if refined sugar could be produced in the North-West Frontier Province, it was realized that even if the sugarcane proved to be of good manufacturing quality and other factors were favourable, a crushing season of 100 days only was hardly sufficient to permit a factory to work at a profit. At the same time it was known that many factories in the sugarcane world have a campaign of not more than 100 days. After some preliminary investigation, it was decided to carry out a series of experiments to find if sugar-beets could be successfully grown in the Peshawar valley, for it was realized that if beets could be supplied from the beginning of April till the end of June, the roots and sugarcane together would enable a factory in the North-West Frontier Province to work for 190 to 200 days, a length of campaign which few sugar factories in the world now enjoy.

40) PROGRESS OF SUGARCANE INDUSTRY IN INDIA, 1916 AND 1917

The tests have confirmed very well the hope that beets of good manufacturing quality can be produced in Peshawar valley from early April until the end of June. No beets have yet been grown by the cultivators, but the trials that have been carried out at Tarnab on areas which have never been less than one acre have demonstrated—

- (1) that it costs Rs. 60 to Rs. 70 to produce about 16 tons of roots per acre ; this price includes rent and all other charges ;
- (2) that beets mature within a period of six to seven months, and contain from 15 to 16 per cent. sucrose when they are ripe ;
- (3) that roots may be supplied to a factory from the 1st April until the end of June ;
- (4) that sugar-beets may be advantageously included in the rotation of crops on the irrigated parts of the Peshawar valley ;
- (5) that the Peshawar cultivators who now grow chillies and sugarcane extensively would have no difficulty in growing beets ;
- (6) that under irrigation the beet crop is a safe one, and it should be very profitable ;
- (7) that the deep red alluvium, almost free of stones, which forms the greater part of the Peshawar valley, is suitable for the production of roots.

It may be added that the by-products in the manufacture of sugar from beets could probably be economically disposed of in the North-West Frontier Province.

III. GENERAL SUMMARY.

- (1) Sugarcane of good manufacturing quality can be produced in the Peshawar valley at Rs. 4 to Rs. 5 per long ton.
- (2) Land and water are available on the banks of the Kabul river for the extension of sugarcane cultivation.
- (3) The Peshawar cultivators are well skilled in the cultivation of cane.
- (4) The landholders on the banks of the Kabul river desire to grow cane for a sugar factory.
- (5) The manufacture of sugar would not affect the out-turn or the price of *gur* in the Peshawar valley.
- (6) Circumstances are generally favourable to the manufacture of refined sugar at Peshawar.
- (7) Sugar-beets with an average of 15 per cent. sucrose can be grown for Rs. 4 to Rs. 5 per ton in the Peshawar valley.

(8) Sugarcane and sugar-beets can be treated for the production of refined sugar in one factory.

(9) Sugarcane and sugar-beets would give a factory at Peshawar a working season of no less than 180 to 200 days.

31st May, 1918.

(11)

ASSAM.

(a)

(A. A. MEGGITT, B.Sc., *Agricultural Chemist and Offg. Deputy Director of Agriculture, Assam Valley.*)

I. MECHANICAL ASPECT.

In the matter of cane-crushing and *gur*-making, our efforts have been confined to the sale of a small 3-roller iron crushing mill capable of doing 2 maunds per hour and costing Rs. 65 in peace times. It is very efficient, giving an expression of 70 per cent. with medium thick canes. Some 54 of the mills have been sold during the last three years in the Assam valley.

The use of shallow evaporating pans in place of deeper vessels is also being pushed.

A factory for the manufacture of white sugar direct from the cane is being erected on the Kamrup farm, *vide* paragraph "Extension Areas" below.

II. AGRICULTURAL ASPECT.

(a) *Survey and testing of local varieties under chemical control.* Several varieties, purporting to be local varieties, have been tested and many rejected at Jorhat in the past, and some are continuously grown against imported varieties for comparison. A good many of these so-called local canes are obviously importations from other parts of India. No complete survey of the canes of the province has been possible up to date. With the expansion of the Department this work will be taken up at Jorhat in the near future with a view to isolate pure types. A sport of one variety, Magh, has been obtained; in field tests it is proving itself superior to its parent, making at least an equal plant crop, and a very much better ratoon.

(b) *Testing such imported varieties as appear prima facie suitable.* This work has been continued actively. The varieties under test include

Striped Mauritius, B. 376, B. 147, B. 208, Barbados A and B (numbers uncertain), B. 6450, B. 3412, B. 1529, Red sport of Striped Mauritius (2), Java (Hebbal), Java 247, Java 33A, Ashy Mauritius, and six other new varieties supplied by Mr. W. Maxwell to the Kamrup farm, whose names and origin were not communicated. Striped Mauritius, B. 376 and B. 147 continued to do well. These varieties were carried on to a factory scale on the Kamrup farm and gave a very good account of themselves, *vide* Kamrup Farm Report for the year ending June 30, 1917. Of the newer varieties, Barbados A, B. 6450, B. 3412 and J. 33A are most promising; Barbados A gave over 39 tons stripped cane per acre from a tenth acre plot last year. J. 33A promises to be a very good cultivator's cane, germinating freely and cropping and tillering well. Many of these varieties have been given field plots this year for the first time. This work is proceeding both in Kamrup and at Jorhat.

(c) *The distribution of the best varieties so determined.* The demand throughout Assam for proved varieties increased enormously, and now far exceeds the supply. In 1916 about 1 lakh of cuttings of Striped Mauritius, B. 376 and B. 147 were distributed; this year over 3½ lakhs were disposed of and this did not meet the demand which is almost entirely the result of actual field demonstration of the superior merits of these canes over local varieties.

(d) *The demonstration of improved mechanical methods.* Demonstrations in the districts of the small three-roller iron bullock mill referred to above and of the use of the shallow evaporating pan have been continued with success. The demand for these mills is in consequence a constantly increasing one, and in this connection there would appear to be a good field for co-operative societies.

Mills and pans are also hired out at a nominal rate.

(e) *The study of questions of tillage, watering, manuring, and drainage, in the light of local conditions, so as to increase the average out-turn per acre.* As regards tillage, experiments have continued in planting methods, using the ridge and furrow system, and varying the spacing of the sets in trenches 3', 4' and 5' apart, respectively. In the result about 8,000 sets per acre planted approximately 2' apart centre to centre in rows 3' apart has given the biggest out-turn.

Experiments in 1916 indicated that not only the number of sets per acre, but also their disposition in the row, may exert considerable influence on the crop. This is being further examined in wide *versus* narrow trenches on the Java model.

Demonstrations in the districts have proved that planting in rows 3 feet apart gives bigger crops than the usual local method of planting in rows so close as to make intercultivation difficult.

Rotation experiments at Jorhat have proved the value to the succeeding cane crop of the following procedure in the year preceding cane—a green crop in the rains, succeeded by a catch crop of rape (*Brassica campestris*) sown early October and ploughed in mid-November, followed by a deep fallow till planting time in February or March.

As to manuring, experiments have continued on :—

- (1) Cake *versus* cowdung ;
- (2) Cake and cowdung *versus* cowdung alone ;
- (3) Raw mineral phosphate in the rotation.

Results will be found in the Jorhat Farm Report for 1916 and 1917.

Respecting drainage, no actual experiments have been made. In view of an outbreak of a *serch*-like disease some years ago, the drainage of all the cane areas has been yearly improved with an almost complete disappearance of the disease.

III. EXTENSION AREAS.

Since the Kamrup farm experiment was last brought before the Board, very great progress has been made, and an extension of operations sanctioned up to March 1919. The disposal of the crop up to that time has been provided for in a contract made by the Local Administration with Mr. W. Maxwell, the cane being sold to him on a sliding scale based upon its sucrose content.

The drainage difficulties which beset us two years ago have been surmounted. With the help of Mr. Milligan (then Imperial Agriculturist) a drainage scheme was worked out, and put into operation early in 1916. This is described in paragraph 11 of the Kamrup Farm Report for 1916. It is sufficient to say here that it has worked admirably : the heaviest falls of rain are quickly removed and the water table has been considerably lowered. During 1916 some 270 acres were under cane—Striped Mauritius, B. 376 and B. 147—and though thin in places, it made a very good average crop. On my computation the crop averaged about 20 tons per acre all over ; it was much higher than this on certain areas which had been reclaimed and opened out 12 months previous to planting, and lower in certain other more recently reclaimed and lower lying parts. Owing largely to delay in the completion of the contract with Mr. Maxwell, a large part of this crop had perforce to be thrown away, rather less than 800 tons being converted into *gur* ; in addition some 2½ lakhs cane sets were distributed from the farm.

The cane was very healthy and ripened off its juice perfectly ; by January 1917 the ratoons contained upwards of 11 per cent. sucrose on cane, while by the end of February the plant cane averaged about

15 per cent. sucrose on cane. For further details see report for 1917.

At present the temporary *gur* factory is being converted into one capable of making white sugar direct from the cane, and it is hoped to convert the crop now on the ground into white sugar during the coming cold weather.

Out of some 600 acres now in cultivation about 500 acres are under cane, plant and ratoon equally. The ratoons came away well, but the cane planted in February and March 1917 suffered somewhat from the drought which followed in March and April this year. The rainfall was also much shorter than usual in May. For these reasons the crop is thin in parts and will probably not come up to last year's general level. From our experience already there is every reason to believe that, given a suitable rotation, the cane crops in the next rotation will be a considerable improvement upon those of the past two years. What we are aiming at is 1,000 acres under cultivation, half in any one year to be under cane and half under green crops recuperating. If the experiment terminates in 1919 or the farm is disposed of then, we shall not have had time even to complete a single course of the rotation, nor to determine whether such a 1,000-acre scheme is beyond the limits of our set of cultivating tackle, nor yet to explore the capacity of the soil for continued production.

4th September, 1917.

(b)

(J. McSWINEY, I.C.S., *Director of Land Records and Agriculture.*)

I have nothing to add to the above note except that financial considerations have been the deciding factor in the intention to dispose of the sugarcane farm in February 1919. We shall have spent over 3 lakhs on the experiment by the end of March 1918 and not improbably 4 lakhs by February 1919: this is a large sum for a small province and I am doubtful whether, if the present financial stringency continues, we could be expected, without assistance, to continue the farm, especially as the original proposal was to limit the expenditure to 2 lakhs and to complete the experiment in three years.

8th September, 1917.

(12)

BURMA.

(T. COOPER, I.C.S., *Director of Agriculture.*)

Economic conditions have become more favourable to the development of the indigenous sugar industry : imports of foreign sugar were, in 1916-17, 260,000 cwt. as against 430,000 cwt.* in 1914-15 and the customs tariff has been doubled. In the two years the area under cane in Burma has risen from 15,362 acres to 18,136 acres.

On the mechanical side nothing has been done by the Department to introduce improved crushing or boiling plant. But a factory to turn out four tons of white sugar and two tons of *jaggery* daily is being erected by private enterprise in the Toungoo District.

The indigenous canes have been collected and are being studied at the Hmawbi farm in Lower Burma. The collection was examined by Dr. Barber at the beginning of this year. He found all Burmese canes to fall under five types, only one of which is a true tropical cane. He was of opinion that better varieties could be substituted for the local canes, and exotics sent by him from Coimbatore are now under trial both in Upper and Lower Burma. No experiments have been made in the production of white sugar, nor have the chemical and agricultural aspects of the palm sugar industry been investigated.

On several of the seed farms and experimental stations cane is being grown, in part as a demonstration. One farm distributed 48,000 sets through the District Agriculturist. In another district a Co-operative Societies Union has been induced to place 30 acres under cane. At the Hopin farm in the north of Upper Burma the out-turn was at the rate of 29 tons an acre ; cattle manure at the rate of 9 tons an acre was used. The Local Government is contemplating the opening of a colony for ticket-of-leave prisoners in this neighbourhood where cane cultivation will be one of the main occupations. The capitalist who is erecting the factory mentioned above has been given much assistance by Mr. McKerral, and Dr. Barber also helped him in determining where the factory could best be located. In order to ensure at the beginning an adequate supply of cane to the factory the Local Government has granted revenue concessions.

17th September, 1917.

* The imports of sugar include molasses, confectionery and saccharin which totalled 19,000 cwt. and 51,000 cwt. in 1916-17 and 1914-15 respectively.

Publications of the Imperial Department of Agriculture in India.

To be had from :—

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar,
and from the following Agents :—

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. Thacker, Spink & Co., Calcutta. 2. W. Newman & Co., Calcutta. 3. Rai M. C. Sarkar Bahadur & Sons, Calcutta. 4. Higginbothams, Ltd., Madras. 5. Thompson & Co., Madras. | <ol style="list-style-type: none"> 6. D. B. Taraporevala, Sons & Co., Bombay. 7. Thacker & Co., Ltd., Bombay. 8. Sunder Pandurang, Bombay. 9. Rai Sahib M. Gulab Singh & Sons, Lahore. 10. Manager, Educational Book Depot, Nagpur. |
|---|--|

A complete list of the publications of the Imperial Department of Agriculture in India
can be obtained on application from the Agricultural Adviser to the Government of India,
Pusa, Bihar, or from any of the above-mentioned agents.

These publications are :—

1. *The Agricultural Journal of India*. A Quarterly Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India. *Annual Subscription*, Rs. 6 or 8s. 6d. including postage. Single copy, Rs. 2 or 3s.
2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist).
3. Annual Report on the Progress of Agriculture in India.
4. Proceedings of the Board of Agriculture in India.
5. Proceedings of Sectional Meetings of the Board of Agriculture.
6. Memoirs of the Imperial Department of Agriculture in India.
 - (a) Botanical Series.
 - (b) Chemical Series.
 - (c) Entomological Series.
 - (d) Bacteriological Series.
 - (e) Veterinary Series.
7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Books.

The following are the publications of the last two years :—

- Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1916-17. Price, As. 9 or 10d.
- Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1917-18. Price, R. 1-4 or 2s.
- Report on the Progress of Agriculture in India for the year 1916-17. Price, As. 12 or 1s. 1d.
- Proceedings of the Board of Agriculture in India, held at Poona on the 10th December, 1917, and following days (with Appendices). Price, As. 13 or 1s. 3d.
- Proceedings of the Mycological Conference, held at Pusa on the 5th February, 1917, and following days. Price, As. 2 or 3d.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

Botanical Series.

- Vol. IX, No. I. The Dissemination of Parasitic Fungi and International Legislation, by E. J. BUTLER, M.B., F.L.S. Price, Rs. 1-4 or 2s.
- Vol. IX, No. II. The Inheritance of Characters in Rice, I, by F. R. PARNELL, B.A., Ag. Dip. (Cantab.); G. N. RANGASWAMI AYYANGAR, B.A., and K. RAMIAH, L.Ag. Price, Rs. 1-8 or 2s.
- Vol. IX, No. III. *Orobanchae* as a Parasite in Bihar, by F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S. Price, Rs. 1 or 1s. 6d.
- Vol. IX, No. IV. Studies in Indian Sugarcanes, No. 3. The Classification of Indian Cane with special reference to the Sarethia and Sunnabile Groups, by C. A. BARBER, sc.D. Price, Rs. 2-4 or 3s.
- Vol. IX, No. V. *Phytophthora Meadii* n. sp. on *Hevea brasiliensis*, by W. McRAE, M.A., B.Sc., F.L.S. Price, Rs. 1-4 or 2s.
- Vol. IX, No. I. The Rice Worm (*Tylenchus angustus*) and its Control, by E. J. BUNN, M.B., F.L.S. Price, Rs. 1-4 or 2s.
- Vol. X, No. II. Studies in Indian Sugarcanes, No. 4. Tillering or underground branching, by C. A. BARBER, C.I.E., sc.D., F.L.S. (In the press.)

Chemical Series.

- Vol. V, No. I. The Gases of Swamp Rice Soils, Part IV. The source of the Gaseous Soil Nitrogen, by W. H. HARRISON, D.Sc.; and P. A. SUBRAMANIAM, B.A. Price, Rs. 2 or 3s. 6d.
- Vol. V, No. II. "Heart Damage" in Baled Jute, by R. S. FINLOW, B.Sc., F.I.C., F.E.S. Price, Rs. 1 or 1s. 6d.
- Vol. V, No. III. Experiments on the Improvement of the Date Palm Sugar Industry in Bengal, by HAROLD E. ANNETT, B.Sc., F.I.C.; GOSTA BEHARI PAL, M.Sc.; and INDU BHUSHAN CHATTERJEE, L.Ag. Price, Rs. 1 or 1s. 6d.
- Vol. V, No. IV. Cholam (*A. Sorghum*) as a Substitute for Barley in Malting Operations, by B. VISWANATH, T. LAKSHMANA ROW, B.A., and RAGHUNATHASWAMI AYYANGAR, Dip. Ag. Price, As. 12 or 1s.

Entomological Series.

- Vol. V, No. II. Indian Sugarcane Leaf-hopper (*Pyrrilla aberrans*, Kirby), by C. S. MISRA, B.A. Price, Rs. 2 or 3s.
- Vol. V, No. III. Report on a Collection of Termites from India, by KARIN and NUS HOLMGREN, Högskolas Zootomiska Institut, Stockholm. Translated by T. BAINBRIDGE FLETCHER, B.N., F.L.S., F.Z.S., F.E.S. Price, Rs. 1 or 1s. 6d.
- Vol. V, No. IV. On a Collection of Sphecoidea sent by the Agricultural Research Institute, Pusa, Bihar, by ROWLAND E. TURNER, F.Z.S., F.E.S. Price, As. 12 or 1s.

Bacteriological Series.

- Vol. I, No. VII. A Bacterial Disease of Wheat in the Punjab, by C. M. HUTCHINSON, B.A. Price, As. 12 or 1s.

Veterinary Series.

- Vol. II, No. VIII. *Kumri*: Combined Diffuse Sclerosis and Central Poliomyelitis of Horses, by G. H. K. MACALISTER, M.A., M.D., D.P.H., M.R.C.S., L.R.C.P. Price, Rs. 1-8 or 2s. 6d.
- Vol. III, No. I. The Vitality of the Rinderpest Virus outside the Animal Body under Natural Conditions, by A. W. SULLSTON, M.R.C.V.S. Price, As. 12 or 1s.

